Eng. Lib.

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DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

Vol. XV AUGUST, 1910 No. 8

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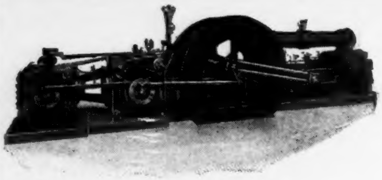

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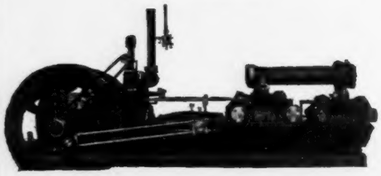
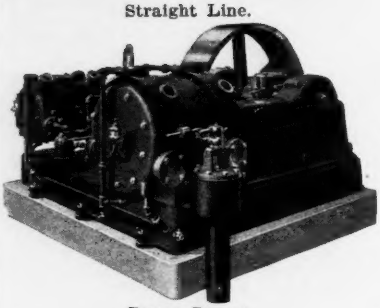


Straight Line.



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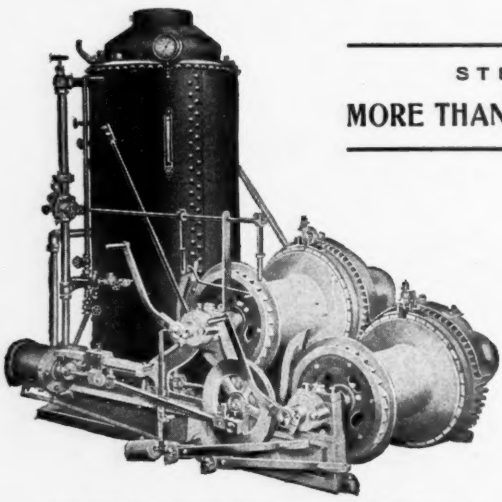

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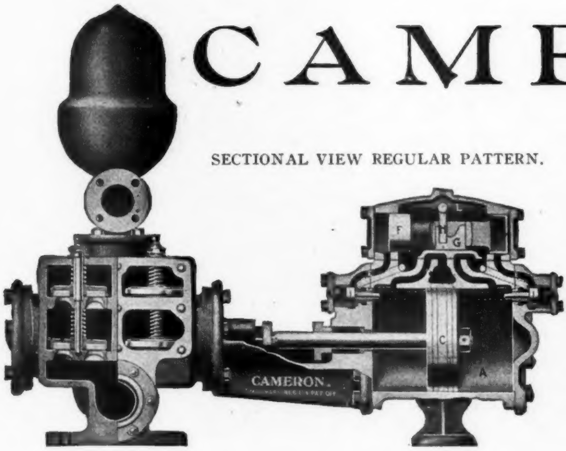

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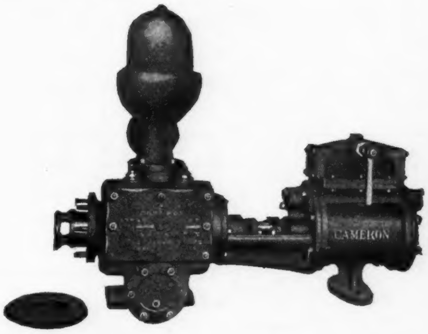

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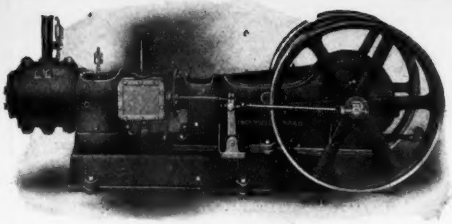

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UNINTERRUPTED SERVICE

There was a time when the choice of an air compressor turned upon the question of price.

But to-day the intelligent buyer places his order with the builder who offers him the best value for the price, whatever that price may be.

Without going into a detailed analysis of what determines compressor **value** (for there are some elements upon which a diversity of views may be held), there are still two fundamentals upon which there can be no argument.

The first essential in the successful air compressor for all-around permanent satisfaction is the ability to deliver uninterrupted service.

The second essential is a true economy of power and up-keep.

There was never yet a **cheap** compressor which measured up to these two fundamental standards.

For, in the very nature of things, the **quality** upon which these two essentials depends cannot be associated with a low first cost.

You do not buy an air compressor as you do a pneumatic tool. In the latter case you drive it to the limit of productive capacity as long as it will stand the pace—and then replace it with a new one. You can afford to do this

But you buy a compressor with a view to its permanent earning capacity. You expect it to be a continuous dividend-paying proposition.

A cheap compressor is never anything but an expense—a continual source of annoyance and repair charges.

But a high-grade, economical air compressor—a machine for uninterrupted service—is the very best kind of an investment.

Consider what uninterrupted service means to you. It means freedom from costly and exasperating break-downs, and few or no repairs. It means a steady maintenance of all operations depending upon the air from that compressor. It means contented workmen carrying on their work with plenty of air pressure on their tools. It means the maximum sustained output from your plant.

And, naturally, the very elements which in a compressor assure this first essential of uninterrupted service, assure also the second essential, which is **a true economy of power and upkeep.** The two are inseparably associated.

For both of these things are primarily a question of **quality;** and quality, in a compressor as in any other machine, comes only from a union of the best talent, the widest experience, the largest facilities, the most approved methods, and the most advanced design.

The Ingersoll-Rand Company with its thirty-nine years of compressor building, is able to offer, in its present line of **twenty standard compressor types,** the quality which is the security of the Company's customers.

Every one of these splendid machines is built for uninterrupted service and maximum economy. The price which they command is recognized by discriminating buyers to represent the maximum compressor value.

From the smallest straight line to the largest duplex Corliss, you can find, in the Ingersoll-Rand line, some **standard** compressor which will be **specially** adapted to your needs.

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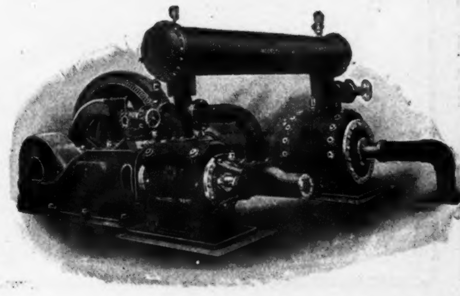

Class "PE-2" Direct Connected Duplex Electric

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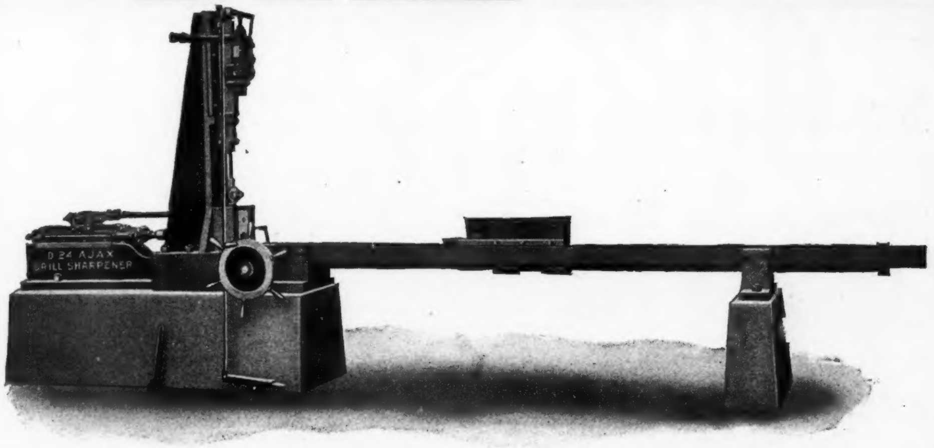
WHY ARE "AJAX" DRILL SHARPENERS SUPERIOR TO ALL OTHERS?



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COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

Vol. XV AUGUST, 1910 No. 8

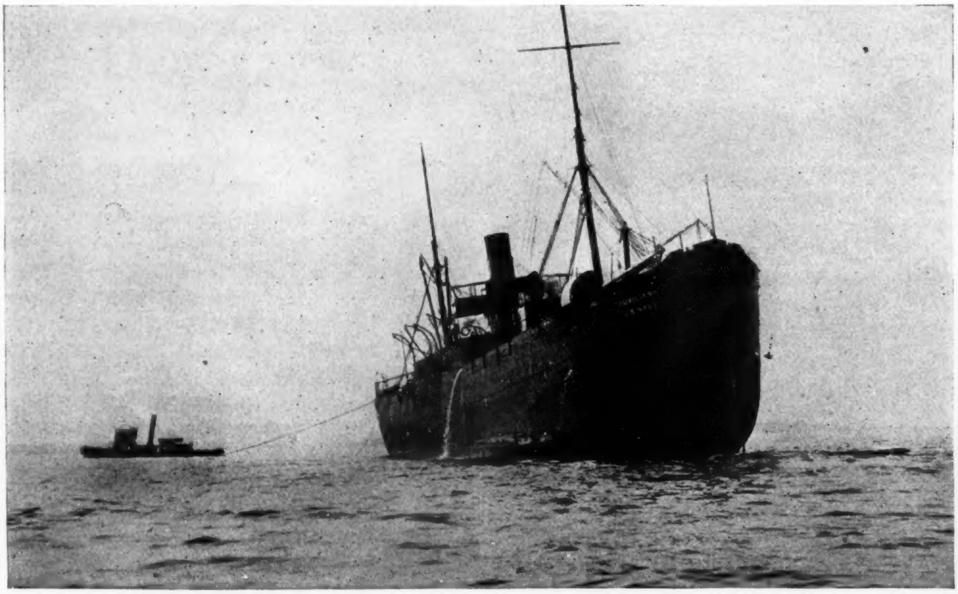
FLOATING AND REPAIRING THE NERO

Although the initial occurrence and the details of some of the later operations have been noted in the daily papers, it is only lately that it has become possible to tell completely the story of the salvage and repair of the valuable United States collier "Nero," which was stranded upon the rocks of Brenton's Reef, near Newport, R. I., about a year ago; and this has now been graphically done in *Reactions,* the attractive quarterly issued by the Goldschmidt Thermit Company, under the permission of the Navy Department, the transactions having been under governmental supervision throughout. What follows is an abstract of the article referred to.

When the Nero was stranded attempts were made on the same day by several naval vessels in the vicinity to float her, but without success. The next day the services of Mr. John Arbuckle, who was at that time engaged in the salvage of the U. S. S. "Yankee," at Buzzards Bay, were secured.

Mr. Arbuckle's men commenced operations on July 3 and the ship was found to be injured quite severely, leaking in nearly all the compartments except the engine and boiler rooms. Powerful pumps were installed to rid the vessel of water, and on July 6 and 7 three attempts were made to float her, but without success, although at one time nine tugs were employed.

Saving the "Nero" by this means having



U. S. S. "NERO" ON THE ROCKS.

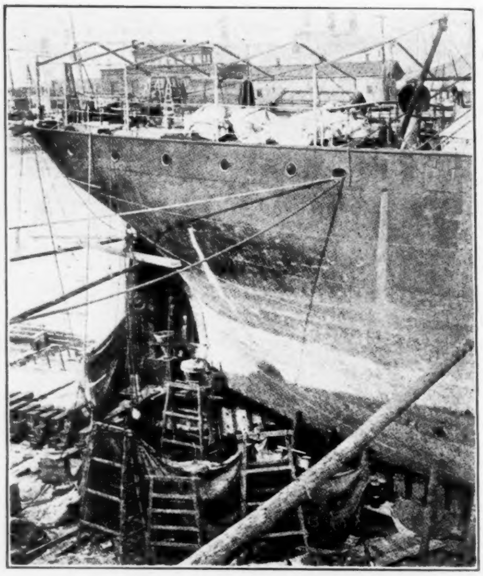
failed, it was decided that the only way of floating the vessel would be to use the compressed-air method which had been successful in other cases, notably the "Mt. Temple," "Bavarian" and "Yankee." The work of closing up the hatchways of the "Nero" by means of steel plates was at once undertaken and an air compressing plant was installed. The now familiar mode of operation is as follows: All openings in the upper parts of the various holds are hermetically sealed, after which compressed air is pumped in and a sufficient pressure is created to drive the water out of the hold through the rents in the bottom. Then workmen, who enter the hold by means of air locks, effect such temporary repairs as are possible.

In the case of the "Nero" the work was nearly completed when a storm caused the ship to shift and in her new position on the rocks a large hole developed in the engine and boiler compartment, which had been dry up to this time. This necessitated the application of compressed air to that compartment also, and the engine and boiler rooms were accordingly made air tight, a task which was completed in less than a week, and which was really a remarkable performance considering the difficulties encountered. An idea of the work involved may be gained from the fact that the ship's engine had to be partially dismantled while the plating put over the fire room made it necessary to cut away the lower part of the ship's smokestack.

On August 1 the work of installing plating, etc., was completed and it was then possible to expel the water from all parts of the ship by pumping in compressed air. On the next day, everything being ready, the tugs made another effort to dislodge the ship and at this attempt, the water being entirely displaced by compressed air, sufficient buoyancy was gained to float the ship, and she was pulled from her position without much difficulty. She was at once taken in tow and the trip to Newport harbor commenced. During this voyage, she remained afloat only because of the air pressure maintained inside of her which prevented water from entering through the many holes in her bottom.

After she was successfully berthed at a dock in the harbor, arrangements were completed to make her sufficiently seaworthy to stand the trip to the Brooklyn Navy Yard. Her hull had been very badly damaged during the stay of a month or more on the rocks, and the many rents in it had to be temporary patched. It was also found that the injuries caused the ship to be structurally weak and considerable work was done in the way of strengthening and reinforcing bulkheads, tank tops, etc.

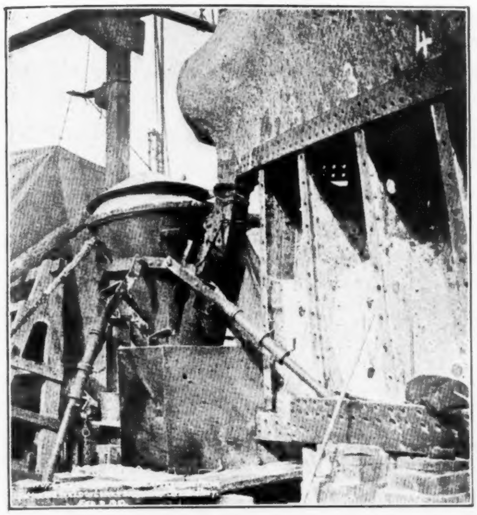
In December the ship was prepared for towage to New York, although during her stay at Newport no active work was done on her for nearly three months. The condition of the ship was such that she would not remain afloat at all without the aid of the compressed-air



IN DRYDOCK—PREPARATIONS FOR TWO WELDS.

plant. The voyage to New York, made December 21-22, was unique on this account. As the engine and boiler compartments were entirely out of commission, being under air pressure, the trip was made with the aid of powerful tugs. During this trip, which lasted twenty-six hours, skilled compressed-air workmen were constantly at work inside of all the compartments to see that nothing gave way.

When the Brooklyn Navy Yard was reached the ship was at once floated into drydock, but as a result of her sojourn on the rocks the contour of her underbody was decidedly irregular. The keel blocks were arranged in conformity with the ship's docking plan, but there were so many rents and dents in the plating that had the ship been let down from the

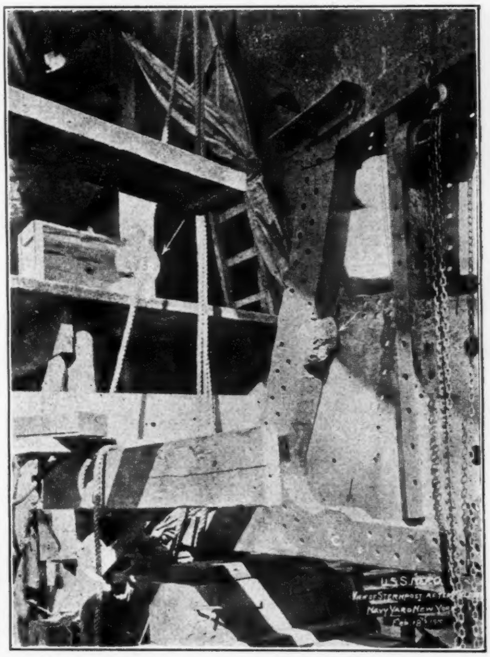


FOR WELDING BREAK IN SHOE.

blocks as they were her weight would have been too unevenly distributed. The water in the dock, therefore, was pumped down only a few feet and then divers were set to work to build up the blocks and shores under the uneven places so as to properly support the vessel. This work occupied about two days before the remainder of the water could be pumped out.

Until the vessel reached her final resting place on the blocks she had been kept afloat in the dock by the ever-useful compressed air, which was only released when the vessel was high and dry on the ways.

It was then possible to obtain an idea of the extent of the injuries which the ship had suffered, and inspection showed that there was hardly a plate in her under bottom in which could not be found either a dent, a crack or a hole. The injuries comprised not only the plates, however, but also the stern-frame of the vessel, which was found to be broken in three places, and which, it was decided by the authorities at the yard, should be welded by the Thermit process.



FINISHED WELDS CHIPPED FLUSH.

The location of the different fractures in the stern-frame are shown in the accompanying illustrations of the Thermit welding operation, work on which was commenced Monday afternoon, January 31 last. On this date the fractures were cut open a distance of 1½ inches to allow for a free flow of Thermit steel so as to effect amalgamation with each side. The ends were then thoroughly cleaned by means of the Niagara Sand Blast and the wax patterns applied in accordance with standard Thermit practice.

WELDING RUDDERPOST AND ONE BREAK IN STERNPOST.

The size of each of the sections to be welded was 6 inches by 10 inches, and the Thermit steel collar provided for was made 8 inches in width by 1½ inches thick at the center, the section of the collar being in the form of a segment of a circle. Mold boxes were then placed in position and the molding material packed around the wax patterns and the wooden patterns used for preheating gate, pouring gate and riser.

The weld in the horizontal member was made first, after which the two vertical members were welded simultaneously, this being done to prevent unequal contraction in cooling. Each of the fractures was brought to a bright red heat by means of a Thermit compressed-air gasoline preheater before the Thermit steel in the crucible was ignited and Thermit steel poured into the mold.

When the welds had entirely cooled the molds were removed and the metal left in the gates and risers cut away. It then became necessary to chip off the collars from two sides of each of the welds in order to permit the plates being replaced. This was done with pneumatic chipping hammers by workmen employed in the Navy Yard.

VARIATIONS OF ATMOSPHERIC PRESSURE AND THE METHANE CONTENT OF PIT AIR*

A number of experiments have shown that the methane content of pit air is influenced by the barometric pressure, inasmuch as the escape of the gas is retarded by increased pressure, and *vice versa,* the rate of change in the outflow being also dependent on the rapidity of the change of pressure, though the maximum or minimum of barometric pressure does not always coincide with a minimum or maximum gas content in the pit air.

The experiments in this direction have recently been continued at the Neunkirchen experimental gallery (Saarbrücken), on a more extended scale and under a wide range of conditions; and the results have been tabulated and plotted in a series of curves. A comparison between the methane curve and the curve of barometric pressure confirms the previous experience that a sharp fall in the latter is accompanied by a sharp rise in the former, and *vice versa,* the maximum and minimum pressures corresponding with minimum and maximum gas-content respectively. Furthermore, the maxima and minima of pressure were found to accord very nearly in point of time with the minima and maxima of gas-content, the interval between them being not more than a few hours at most. The agreement between the two was found closest where a rapid rise of pressure followed a sudden fall, the reversal of the curve being then frequently followed at once by a corresponding bend in the methane curve.

Very different results were obtained in the cases where the barometric pressure remained for some time approximately constant after reaching a maximum or minimum, or gradually rose or fell after being steady for some considerable time. In these circumstances, no direct influence of the pressure on the liberation of gas could be traced, the methane curve tending to remain steady, with merely slight fluctuations, until the next considerable variation of the barometer. When the steady pressure had been preceded by a maximum, the methane curve continued to rise to a certain height or to descend for a certain extent under the converse conditions, the ratio between the pressure and the methane curves being about the same in both cases. Consequently, slow changes in the height of the barometer have no appreciable effect on the course of the methane curve. The independence of the gas content, in the return-air current, with relation to the barometric pressure was confirmed by observations showing that the amplitude of the monthly variations in the methane content does not coincide at all with that of the atmospheric pressure, the former being frequently less in months when the barometric fluctuations were considerable than when these were slight. Analogous results were obtained by comparing the mean monthly barometric readings and methane content. If the volume of gas liberated were dependent entirely on the higher or lower barometric pressure, the months with a high mean position of the barometer would show a low mean gas content, and *vice versa,* which is by no means the case. Furthermore, it appears that the mean gas content in any mine is a fairly constant factor (so long as the prevailing conditions of working remain unaltered), which does not vary except as the result of considerable fluctuations in the atmospheric pressure.

**Zeitschrift für das Berg-, Hütten- und Salinenwesen.*

The behaviour of the methane curve toward the barometer curve is capable of explanation by an examination of the factors determining the liberation of gas from the standing coal or from cavities. In the case of the coal the gas makes its way through fissures or from the exposed face; and in the former case the outburst usually occurs under such considerable pressure that the atmospheric pressure can have no appreciable influence thereon. In the case of the exposed coal a distinction must be drawn between coal that has already been got down, or is still hanging loosely to the face, and the actual firm standing coal. The first of these categories also includes undercut or blasted coal still lying at the working places, and such as is already loaded into the tubs. In this case the gas is no longer under pressure, so that it does not escape so long as the barometer remains steady. As soon, however, as the atmospheric pressure falls, the gas molecules expand and escape from the pores in the coal; and conversely, a rise in the barometer is accompanied by a penetration of air into the outer strata of the coal. Gas standing in the goaf or other cavities behaves in a similar manner, and apart from the results of diffusion, such gas does not increase the gas content of the pit air, except when the barometer falls. The degree of enrichment will be in proportion to the rapidity of the fall in pressure; and as soon as the downward movement of the barometer ceases, the escape of gas from the pores of the loose coal, or out of the cavities, is terminated for the time being.

The firm, standing coal, however, is a constant source of gas. Numerous experiments have proved that the gas is imprisoned in the seams under heavy pressure, which pressure gradually diminishes the nearer the coal face, so that it escapes there under merely slight pressure, that oftentimes is so near that of the atmosphere that no difference can be ascertained. Assuming the resistance offered by the pores of the coal to be a constant factor, the volume of the escaping gas depends on the difference between the pressure in the interior of the coal and the atmospheric pressure. Consequently, slight fluctuations in the latter—which amount to barely 1 per cent. of the former—cannot lead to any appreciable increase or diminution in the volume of gas liberated. The only occasions on which such changes in the escape of gas can occur are when the atmospheric pressure alters so rapidly the epuilibrium of the internal gas pressure is precluded. Whether, however, such disturbances of the regular escape of gas actually occur on sudden barometric fluctuations, is improbable. In any event they would be of merely brief duration, and would influence the behaviour of the gas curve in only the same manner as transitory liberations of gas from the loose coal or cavities, the gas curve tending always to return to a position corresponding with the mean liberation of gas, even in the case of a protracted barometric maximum or minimum succeeding a sudden change of pressure.

AMMONIA COMPRESSORS

By C. P. Wood.

Compressors may be vertical or horizontal, single- or double-acting, simple or compound. They may be cooled by oil or by a water jacket, or by saturated NH_3 gas.

Advantages claimed for vertical machines are, among others, small friction loss and consequent decrease in wear of piston and cylinder, also less probability of leakage due to worn cylinder or piston. Another advantage is that the rod does not rest heavily on the packing in the stuffing box, making it easier to keep the packing perfectly tight.

For the horizontal type, it is claimed that it will pump equally well either dry or saturated gas, that it requires very little more floor space than a vertical machine and much less head room, that the moving parts being near the base makes it easier for the strains to be resisted by the foundations, that all the parts are easily accessible from the floor.

An advantage of single-acting machines is that by the use of a safety head and a valve in the piston they can be operated without any clearance between piston and head, thus preventing one of the usually serious losses. Another advantage is that by using only the head end of the cylinder for compression, there is no loss due to leakage around the rod through the stuffing box, the pressure there being no higher than suction.

The double-acting machines, giving compression at each end of the stroke, have obvious advantages in high efficiency of both the steam and ammonia sides of the system, when all parts are considered at the same time instead of separately. The clearance loss has

been reduced to a minimum in the best designs.

The loss due to clearance may be explained as follows: Suppose the high-pressure ammonia equals 180 pounds and the low-pressure 20 pounds; then the ratio is 1 to 9. Therefore, if the clearance equals 1/9 inch, the gas left in cylinder at the end of the compression stroke will take up 1 inch of space during suction stroke, keeping out that much fresh gas and reducing capacity accordingly.

This explains the desirability of having the piston travel the full length of the cylinder every stroke. The practical disadvantage of this is that when foul ammonia liquid or oil is drawn in in very large quantity, or when a valve breaks and gets into the cylinder, the machine is liable to be wrecked.

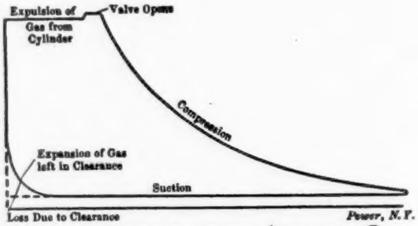
In single-acting vertical machines, the head can be held on by springs, strong enough to withstand the working pressure, which will relieve the machine in a case like that described.

In the De la Vergne system, oil is injected into the cylinder after the beginning of compression; this fills the clearance space, insuring complete expulsion of the gas, and is released through a passage which opens at the end of the stroke. Another function of this oil, which is cooled in a special oil cooler, is to take up the heat generated during compression, there being no water jacket to the cylinder.

Siebert has patented a bypass which opens at the end of the stroke, allowing the compressed gas confined in clearance to escape from the compression to the suction side of the piston.

It can be seen from the foregoing that the working space allowed for suction valves will have the same effect as clearance. When located in the heads, these valves are designed to fit flush, reducing loss as much as possible. The suction valve area generally allows for a gas velocity of about 4,000 to 4,500 feet per minute. The "Triumph" design has strainers over inlet valves to keep foreign substances out of the cylinder.

The accompanying indicator diagram shows graphically the cycle of events in the compressor cylinder. The space between the curve and the dotted line in the lower left-hand corner represents the loss due to clearance. The line of gas expulsion is perfectly straight when the valve works perfectly. The distance between the atmospheric line and the suction line represents suction pressure. Close-grained hammered steel, with a tensile strength about 75 per cent. greater than cast iron, is generally used for the manufacture of compressor cylinders.



INDICATOR DIAGRAM FROM AMMONIA COMPRESSOR

The stuffing box is an important part, especially in double-acting machines. Is is often divided into several compartments, sometimes employing oil or water under pressure. The cylinder should have indicator connections and provision for thermometers at the inlet and discharge. There should be a bypass, connected in such a way as to make it possible to exhaust the condensor by pumping the entire charge into the refrigerator, or *vice versa.*

The capacity of compressors is rated in two ways; (a) Ice-making capacity (tons of ice made in twenty-four hours); (b) refrigerating capacity (cooling work compared with melting one ton of ice in twenty-four hours). Power for driving compressors is provided at the rate of from 1.5 to 3 horsepower per ton of refrigerating capacity, depending upon the size of the machine. Except in very small machines, common practice is to drive with the Corliss engine. A popular design is a vertical compressor driven by a horizontal Corliss, the engine connecting rod and compressor connecting rod being mounted on the same crank pin. This is a good, compact design, especially with a twin compressor and cross-compound engine. The objection is that the length of stroke of the engine is limited to that of the compressor when a longer engine stroke would be more economical. There is a successful tandem horizontal design, i. e., with the ammonia-compressor piston mounted on the extension of the steam piston rod.

Compressors must have very heavy fly-

wheels to insure uniformity of motion. In the best designs for gas-engine drive, the engine is belted to a countershaft, which is belted to the compressor. In case of electric-motor drive, the power is best transmitted by gears or by a noiseless chain of the Morse type.

ATMOSPHERIC HUMIDITY*

By Dr. William M. Grosvenor.

The following methods were developed as a matter of commercial necessity. They were needed to design a great number of drying installations adapted to meet widely different requirements, operating under a system the advantages of which have hitherto been largely overlooked, i. e., the repeated circulation of the same air over condensing coils to remove moisture, over heating pipes to increase the moisture capacity, over the material being dried, and again over the condenser.

Surprising steam economies are thus accomplished, in some cases amounting to more than 80 per cent. Insurance risks are reduced. So-called "moist drying" becomes a matter of course, great capacity is permitted, and complete independence of climatic conditions makes accurate design and perfect regulation possible.

The engineering of drying is to-day one of the most neglected and by no means one of the most simple branches of applied science. There are thousands of installations where the air is taken from the streets and the gutters and blown loaded with bacteria over fermentive products (many of them food stuffs), where it is received ice cold and heated up to 50 degrees or 100 degrees before it begins to do its profitable work, or is drawn in nearly saturated at 85 degrees to dry a product which cannot safely be heated above 95 degrees, where, worst of all, it is expected to reverse the performance of the widow's oil jug, and to keep on drinking up moisture indefinitely without renewal or dehydration. Taking advantage of the variable weather conditions, which the seller of machinery had no object in controlling, the machinery was made big enough—the bigger the better.

In developing simple, rapid, and at the same time reasonably accurate methods of design, we were met at once with the fundamental difficulty that there is no simple equation expressing the relation between the tension of aqueous vapor and the amount of water, either by volume or weight, saturating air under given conditions.

The next difficulty was that the base or divisor (cubic foot) of all humidity calculations has hitherto been most unfortunately selected, as it varies with every change of pressure, temperature, or humidity, needlessly complicating all calculations. Lastly that "percentage humidity," more properly called "degree of humidity," is not really comparable percentage at all. Ten per cent. of humidity means that 1 cu. ft. of moisture contains one-tenth the amount of water which a cubic foot of another mixture containing less air would carry if saturated under the same conditions of temperature and pressure.

While such a standard of humidity may be satisfactory for meteorological records, practical design in a field thus obstructed was a dangerous thing to turn over to subordinates, and it seemed advisable to begin by getting rid of stumpage and doing some grading. Finally there was marked disagreement in published tables of the essential constants.

The last question was first taken up. The original sources were examined and an entirely new set of calculations was made from vapor tensions to weight of water per cubic foot, using the following formulae and constants:

Density of air + .04% $CO_2 = \frac{1.293052}{1 + .00367 \times \text{Temp. C.}}$ in kg per cu. m).

Density of water vapor = .62186 × density air.

Ratio of density at partial pressure to density at 760 mm = 1/760 × partial pressure in mm.

Wt. in kg of 1 cu. m of residual air = 1/760 × part. press. × density of air (in kg per cu. m).

Wt. in kg of 1 cu. m of water vapor at part. pressure = 1/760 × 0.62186 part. pressure × density of air.

Specific heat water vapor = .475.

Specific heat of air = .2373.

Kg per cu. meter × .062428 = lb. per cu. ft.

Results of these calculations are given for every degree Fahrenheit in the table on the following page.

These results (Col. 3), differed by as much as 4 per cent. from the various published fig-

*Reprinted from *Metallurgical and Chemical Engineering*, this being a part only of an abstract of a paper presented under a different title, at the Pittsburg meeting of the American Institute of Chemical Engineers.

Temp. F.	Vapor Tension in Millimeters	Lbs. Water Vapor per Pound Air	Humid Heat in B.T.U.	Humid Volume in Cu. Ft.	Density in Lbs. per Cu. Ft. @ 760 Millimeters		Specific Volume in Cu. Ft. per Lb. of—	
					Dry Air	Sat'd Mix.	Dry Air	Sat'd Mix.
1	2	3	4	5	6	7	8	9
32	4.569	.003761	.2391	12.462	.080726	.080556	12.388	12.414
33	4.746	.0039176	.2392	12.491	.080559	.080377	12.413	12.442
34	4.949	.0040763	.2392	12.521	.080393	.080198	12.439	12.469
35	5.152	.0042435	.2393	12.549	.080231	.080025	12.464	12.496
36	5.358	.0044151	.2394	12.578	.080069	.079852	12.489	12.523
37	5.572	.0045931	.2395	12.606	.079910	.079680	12.514	12.549
38	5.795	.0047781	.2396	12.636	.079748	.079511	12.539	12.576
39	6.023	.0049678	.2397	12.666	.079585	.079343	12.565	12.604
40	6.264	.0051678	.2398	12.695	.079420	.079181	12.590	12.629
41	6.507	.0053703	.2399	12.724	.079272	.079012	12.615	12.655
42	6.764	.0055849	.2400	12.754	.079113	.078849	12.640	12.682
43	7.026	.0058025	.2400	12.784	.078954	.078677	12.666	12.710
44	7.301	.0060320	.2401	12.813	.078797	.078514	12.692	12.736
45	7.582	.0062670	.2403	12.843	.078641	.078348	12.718	12.763
46	7.874	.0065103	.2404	12.872	.078485	.078178	12.741	12.791
47	8.177	.0067636	.2405	12.904	.078329	.078011	12.766	12.819
48	8.486	.0070239	.2407	12.935	.078172	.077844	12.792	12.846
49	8.811	.0072942	.2408	12.968	.078019	.077678	12.817	12.874
50	9.140	.0075697	.2409	12.999	.077867	.077511	12.842	12.901
51	9.488	.0078620	.2410	13.030	.077714	.077344	12.868	12.927
52	9.841	.0081579	.2411	13.062	.077562	.077178	12.893	12.957
53	10.210	.0084683	.2413	13.095	.077409	.077016	12.919	12.984
54	10.589	.0087865	.2415	13.127	.077258	.076851	12.944	13.012
55	10.980	.0091163	.2416	13.159	.077109	.076685	12.968	13.041
56	11.386	.0094583	.2418	13.192	.076926	.076522	12.993	13.068
57	11.801	.0098064	.2420	13.224	.076810	.076363	13.019	13.096
58	12.235	.010165	.2421	13.258	.076661	.076198	13.044	13.124
59	12.674	.010546	.2423	13.292	.076512	.076032	13.070	13.152
60	13.138	.010939	.2425	13.326	.076363	.075865	13.095	13.180
61	13.608	.011338	.2427	13.360	.076215	.075698	13.121	13.210
62	14.100	.011755	.2429	13.395	.076069	.075529	13.146	13.240
63	14.603	.012182	.2431	13.431	.075924	.075362	13.171	13.270
64	15.122	.012625	.2433	13.467	.075799	.075198	13.196	13.298
65	15.600	.013081	.2435	13.501	.075635	.075039	13.222	13.325
66	16.209	.013547	.2438	13.535	.075493	.074882	13.246	13.354
67	16.783	.014043	.2440	13.572	.075347	.074718	13.272	13.384
68	17.363	.014539	.2442	13.609	.075201	.074552	13.298	13.413
69	17.975	.015065	.2444	13.645	.075062	.074387	13.323	13.441
70	18.595	.015597	.2447	13.683	.074921	.074219	13.348	13.471
71	19.242	.016154	.2450	13.720	.074778	.074054	13.373	13.502
72	19.903	.016724	.2452	13.759	.074636	.073899	13.398	13.532
73	20.585	.017312	.2455	13.797	.074496	.073735	13.424	13.562
74	21.289	.017922	.2458	13.837	.074363	.073570	13.449	13.593
75	22.008	.018545	.2461	13.876	.074218	.073405	13.474	13.624
76	22.759	.019198	.2464	13.916	.074079	.073239	13.499	13.654
77	23.517	.019857	.2467	13.956	.073940	.073072	13.524	13.685
78	24.315	.020554	.2470	13.997	.073801	.072909	13.549	13.715
79	25.124	.021260	.2474	14.039	.073663	.072747	13.575	13.746
80	25.965	.021998	.2478	14.081	.073531	.072585	13.600	13.777
81	26.724	.022752	.2481	14.123	.073395	.072419	13.625	13.809
82	27.711	.023532	.2485	14.167	.073258	.072248	13.650	13.841
83	28.625	.024339	.2488	14.211	.073123	.072080	13.675	13.873
84	29.557	.025164	.2492	14.255	.072987	.071913	13.701	13.906
85	30.529	.026026	.2497	14.301	.072852	.071744	13.726	13.938
86	31.519	.026898	.2501	14.347	.072716	.071574	13.752	13.971
87	32.518	.027818	.2505	14.399	.072584	.071404	13.776	14.004
88	33.582	.028750	.2510	14.442	.072453	.071234	13.801	14.038
89	34.667	.029724	.2514	14.490	.072321	.071064	13.827	14.072
90	35.774	.030718	.2519	14.539	.072189	.070894	13.852	14.106
91	36.913	.031747	.2524	14.588	.072058	.070724	13.787	14.139
92	38.087	.032810	.2529	14.638	.071926	.070556	13.903	14.173
93	39.283	.033896	.2534	14.688	.071794	.070390	13.929	14.206
94	40.528	.035029	.2539	14.740	.071664	.070221	13.954	14.241
95	41.784	.036174	.2545	14.793	.071535	.070051	13.979	14.275
96	43.102	.037388	.2550	14.846	.071407	.069878	14.004	14.310
97	44.434	.038603	.2556	14.900	.071279	.069704	14.030	14.346
98	46.824	.039817	.2562	14.956	.071149	.069530	14.055	14.582
99	47.228	.041206	.2569	15.013	.071021	.069356	14.080	14.419
100	48.679	.042557	.2575	15.071	.070894	.069179	14.106	14.455
101	50.171	.043955	.2582	15.131	.070767	.069002	14.131	14.492
102	51.691	.045382	.2589	15.192	.070641	.068825	14.155	14.530
103	53.271	.046876	.2596	15.253	.070514	.068645	14.181	14.568
104	54.865	.048385	.2603	15.313	.070387	.068464	14.207	14.606
105	56.534	.049973	.2610	15.376	.070264	.068288	14.232	14.643
106	58.219	.051582	.2618	15.440	.070141	.068110	14.257	14.682
107	59.968	.053271	.2626	15.506	.070018	.067926	14.282	14.722
108	61.749	.054996	.2634	15.572	.069894	.067745	14.307	14.761
109	63.578	.056634	.2643	15.640	.069751	.067568	14.333	14.800
110	65.459	.058613	.2651	15.711	.069647	.067383	14.358	14.840
111	67.374	.060492	.2660	15.783	.069525	.067192	14.384	14.883
112	69.359	.062456	.2670	15.854	.069403	.067007	14.409	14.924
113	71.362	.064442	.2679	15.930	.069281	.066823	14.434	14.965
114	73.455	. 66540	.2689	16.006	.069167	.066636	14.459	15.008
115	75.569	.068662	.2699	16.084	.069040	.066447	14.484	15.050
116	77.757	.070881	.2710	16.164	.068920	.066253	14.509	15.094
117	79.986	.073150	.2720	16.245	.068800	.066061	14.535	15.137
118	82.273	.075514	.2732	16.328	.068681	.065871	14.560	15.179
119	84.621	.077921	.2743	16.413	.068562	.065675	14.585	15.225
120	87.010	.080402	.2755	16.499	.068443	.065477	14.611	15.272
121	89.479	.082995	.2767	16.592	.068325	.065280	14.636	15.319

Temp. F.	Vapor Tension in Millimeters	Lbs. Water Vapor Per pound Air	Humid Heat in B. T. U.	Humid Volume in Cu. Ft.	Density in Lbs. per Cu. Ft. @ 760 Millimeters		Specific Volume in Cu. Ft. per Lb. of—	
					Dry Air	Sat'd Mix.	Dry Air	Sat'd Mix.
1	2	3	4	5	6	7	8	9
122	91.978	.085622	.2780	16.679	.068207	.065082	14.661	15.365
123	94.581	.088398	.2793	16.777	.068090	.064884	14.686	15.412
124	97.207	.091208	.2806	16.870	.067973	.064689	14.711	15.460
125	99.924	.094147	.2820	16.968	.067857	.064480	14.736	15.509
126	102.688	.09716	.2835	17.069	.067741	.064277	14.762	15.558
127	105.518	.10027	.2849	17.172	.067625	.064075	14.788	15.606
128	108.428	.10350	.2864	17.278	.067510	.063870	14.813	15.657
129	111.382	.10680	.2880	17.386	.067394	.063663	14.838	15.708
130	114.437	.11032	.2896	17.499	.067280	.063449	14.863	15.761
131	117.516	.11368	.2913	17.612	.067166	.063234	14.888	15.814
132	120.724	.11742	.2931	17.730	.067052	.063022	14.914	15.867
133	123.960	.12121	.2949	17.851	.066938	.062809	14.939	15.921
134	127.304	.12514	.2968	17.976	.066826	.062591	14.964	15.977
135	130.702	.12917	.2987	18.103	.066713	.062374	14.989	16.032
136	134.182	.13335	.3006	18.235	.066601	.062158	15.015	16.088
137	137.749	.13768	.3026	18.370	.066489	.061939	15.040	16.145
138	141.372	.14122	.3047	18.508	.066377	.061717	15.065	16.204
139	145.114	.14678	.3070	18.653	.066267	.061487	15.090	16.264
140	148.885	.15150	.3093	18.800	.066156	.061255	15.116	16.325
141	152.807	.15652	.3117	18.952	.066045	.061022	15.141	16.387
142	156.762	.16161	.3141	19.108	.065935	.060790	15.166	16.450
143	160.841	.16696	.3166	19.270	.065823	.060554	15.192	16.512
144	164.986	.17245	.3192	19.437	.065712	.060318	15.217	16.576
145	169.227	.17816	.3219	19.609	.065601	.060082	15.242	16.643
146	173.569	.18409	.3247	19.787	.065498	.060842	15.267	16.710
147	177.976	.19017	.3276	19.971	.065390	.060599	15.293	16.780
148	182.522	.19659	.3307	20.161	.065283	.060353	15.318	16.846
149	187.103	.20310	.3338	20.354	.065176	.059106	15.343	16.919
150	191.860	.21005	.3371	20.559	.065068	.058865	15.368	16.993
151	196.654	.21710	.3404	20.767	.064962	.058605	15.394	17.068
152	201.595	.22455	.3440	20.987	.064856	.058349	15.419	17.141
153	206.610	.23221	.3476	21.211	.064750	.058092	15.444	17.215
154	211.739	.24019	.3514	21.445	.064644	.057833	15.469	17.291
155	216.983	.24854	.3553	21.687	.064539	.057570	15.494	17.370
156	222.305	.25713	.3594	21.936	.064425	.057305	15.520	17.450
157	227.786	.26623	.3637	22.201	.064328	.057036	15.545	17.533
158	233.308	.27546	.3681	22.468	.064224	.056767	15.570	17.616
159	239.034	.28542	.3728	22.754	.064120	.056493	15.596	17.701
160	244.803	.29553	.3776	23.045	.064016	.056218	15.621	17.788
161	250.742	.30627	.3827	23.382	.063913	.055938	15.646	17.877
162	256.767	.31737	.3880	23.670	.063810	.055656	15.671	17.968
163	262.923	.32900	.3936	24.001	.063707	.055372	15.697	18.060
164	269.213	.34123	.3994	24.349	.063605	.055084	17.722	18.154
165	275.592	.35385	.4054	24.708	.063502	.054795	15.748	18.250
166	282.155	.36733	.4118	25.090	.063400	.054500	15.772	18.349
167	288.764	.38106	.4183	25.478	.063298	.054203	15.798	18.449
168	295.609	.39602	.4254	25.900	.063198	.053901	15.823	18.545
169	302.504	.41125	.4327	26.300	.063098	.053598	15.848	18.654
170	309.593	.42756	.4405	26.790	.062997	.053292	15.874	18.761
171	316.781	.44472	.4485	27.267	.062899	.052983	15.899	18.875
172	324.120	.46257	.4570	27.768	.062799	.052670	15.924	18.986
173	331.612	.48162	.4660	28.301	.062699	.052353	15.949	19.101
174	339.207	.50140	.4754	28.855	.062599	.052032	15.975	19.218
175	347.015	.52285	.4856	29.454	.062500	.051708	16.000	19.339
176	354.873	.54472	.4960	30.063	.063402	.051382	16.025	19.462
177	363.003	.56901	.5076	30.738	.062304	.051049	16.050	19.589
178	371.190	.59386	.5194	31.428	.062207	.050715	16.076	19.719
179	379.598	.62097	.5322	32.180	.062112	.050378	16.101	19.851
180	388.121	.64942	.5458	32.967	.062015	.050035	16.126	19.987
181	396.815	.67985	.5602	33.810	.061915	.049693	16.152	20.126
182	405.686	.71265	.5758	34.717	.061816	.049338	16.177	20.269
183	414.674	.74703	.5921	35.666	.061719	.048985	16.202	20.415
184	423.904	.78519	.6102	36.718	.061623	.048626	16.227	20.566
185	433.194	.82430	.6288	37.796	.061529	.048265	16.253	20.719
186	442.793	.86911	.6501	39.029	.061434	.047898	16.278	20.879
187	452.456	.91535	.6721	40.302	.061339	.047529	16.303	21.041
188	462.374	.96731	.6967	41.729	.061244	.047153	16.328	21.209
189	472.422	1.0227	.7230	43.251	.061149	.046774	16.353	21.381
190	482.668	1.0835	.7519	44.918	.061053	.046391	16.379	21.557
191	493.111	1.1510	.7843	46.768	.060961	.046003	16.404	21.739
192	503.690	1.2230	.8190	48.739	.060867	.045611	14.429	21.925
193	514.545	1.3067	.8579	51.021	.060774	.045213	16.454	22.119
194	525.368	1.3933	.8990	53.402	.060681	.044813	16.480	22.315
195	536.744	1.4994	.9494	56.302	.060588	.044405	16.505	22.521
196	548.093	1.6108	1.0023	59.349	.060496	.043997	16.530	22.730
197	559.731	1.7436	1.0714	62.978	.060403	.043586	16.556	22.945
198	571.519	1.8912	1.1358	67.024	.060311	.043169	16.581	23.166
199	583.531	2.0629	1.2171	71.696	.060219	.042742	16.606	23.393
200	595.771	2.2680	1.3147	77.304	.060127	.042308	16.631	23.638
201	608.155	2.4968	1.4231	83.537	.060036	.041868	16.656	23.886
202	620.871	2.7987	1.5665	91.768	.059946	.041425	16.682	24.142
203	633.657	3.1189	1.7186	100.499	.059855	.040982	16.707	24.401
204	646.845	3.6509	1.9159	115.210	.059764	.040530	16.732	24.675
205	660.116	4.2272	2.1562	131.028	.059674	.040075	16.758	24.954
206	673.718	4.9776	2.5681	151.272	.059585	.039610	16.783	25.248
207	687.489	6.0698	3.1238	180.906	.059495	.039143	16.808	25.549
208	701.516	7.6748	3.8948	224.623	.059406	.038673	16.834	25.860
209	715.805	11.1295	6.2569	362.091	.059317	.038049	16.858	26.289
210	730.267	15.8174	15.9148	562.054	.059228	.037323	16.884	26.796

ATMOSPHERIC HUMIDITY TABLE.

ures, but showed a surprising agreement (¼ per cent. due to allowance of 0.04 per cent. CO_2) with the figures of the United States Weather Bureau. The reason for this was inquired into. Quoting from the Psychrometric Tables of the United States Weather Bureau of 1900 (prepared by Dr. C. F. Marvin, Professor of Meteorology), it will be seen how carefully the Weather Bureau's table were prepared:

"The vapor pressures employed were derived from Broch's reduction of Regnault's observations. All the values given by these tables at temperatures below the freezing point are noticeably higher than Regnault's observations. In view of this systematic discordance and the further circumstance that Regnault's experiments did not include observations at the extremely low temperatures frequently recorded at Weather Bureau stations, the writer (Dr.

Marvin), in 1891, made a new determination of the maximum pressure of aqueous vapor at low temperatures.

"In the course of these experiments it was found an easy matter to reduce the temperature of the water employed many degrees below 32 degrees Fahr., without freezing it, and in these cases the vapor pressure was higher than the pressure from ice at the same temperature. Independent experiments in Sweden, by Julius Johlin, at about this time, led to the same results.

"A comparison of the vapor pressures derived from the several sources mentioned shows that Broch's computed values at low temperatures do not agree at all well with Regnault's experiments, from which they are derived, whereas the experimental results of Regnault, Johlin, and the writer (Dr. Marvin), agree very closely.

"At temperatures below 32 degrees Fahr., therefore, it has been considered necessary to reject Broch's values, and the vapor pressures over ice, as deduced from the writer's experiments, have been used in the calculation of the tables. At temperatures above 32 degrees Fahr. the values taken from Broch's tables are employed. At 32 degrees Fahr. the value for the vapor pressure found by the writer from the mean of a large number of experiments was identical with that of Broch; hence, there is no break in the continuity of the two tables at the point of junction."

The calculated weight of water per pound of air does not agree with actual determinations, but shows progressive differences, possibly owing to association of molecules in the vapor, which are too small in magnitude, however, to affect our present purpose.

Regarding this difference Dr. Marvin writes:

"In all ordinary circumstances it is assumed that the expansion and contraction of partially saturated aqueous vapor is in accordance with the same laws as apply to air and ordinary gases, which do not easily condense to the liquid state.

"The adopted density of saturated aqueous vapor is not determined directly from experiment, but is deduced theoretically from the observed fact that two volumes of hydrogen and one of oxygen combine to produce two volumes of water vapor.

"The weights of unit volumes of hydrogen, oxygen, and dry air are accurately known, from which the specific gravity of aqueous vapor is found to be 0.6221."

The compared figures from various sources were submitted to Dr. Marvin, but he replied that, "The Weather Bureau has not attempted to measure the quantity desired directly; in fact, the difficulty of experimentally maintaining a condition of absolute saturation and avoiding supersaturation, or mechanically suspended moisture on the one hand and superheating on the other, is so great as to perhaps render the results thus obtained less acceptable than the theoretical values."

We must, therefore, accept these figures as generally recognized throughout the United States and at least as well established as our purpose requires.

COMPUTING THE FORCE OF A HAMMER BLOW

By S. B. Redfield.

Some time ago the catalog of a manufacturer of rock drills came into my hands and under the specifications of each of the different sizes of drill was given the item "Force of the Blow Delivered."

Upon taking up the matter with the manufacturers' engineers, as a matter of interest, it was admitted that nobody knew where the figures had come from, nor how they were calculated. They had simply been handed down from edition to edition of the catalog, always using the previous edition as authority.

In Kent's "Mechanical Engineers' Pocket Book," on page 430, is the following statement referring to the question of the force of a blow: "The question cannot be answered directly and it is based upon a misconception or ignorance of fundamental mechanical laws."

There is a great deal of this "misconception" (I hesitate to say "ignorance") and some remarks on the subject should be of interest.

When a body of a given weight is lifted through a given distance, work is done upon that body against the action of gravity, equal to the product of the weight by the distance lifted through. When this body is allowed to fall again, this work is transformed into energy of motion and when the body strikes an obstacle, the act of stopping the body forces it to give up its energy of motion, resulting in deformation or breakage and heat.

Just as the work done upon the body in

lifting it against gravity is the product of a force (weight) and a distance (height) so the work done when the body stops falling must be the product of a force and a distance. The distance is the penetration of one of the bodies into the other, or the deformation, and the force exerted is the "force of the blow" about which we are talking. As the work done by the blow must equal the work stored in the falling body, the product of the force of the blow and the depth of penetration must be constant and equal to this stored work. If the substances are tough and penetration is slight, the force of the blow must be correspondingly great. Similarly, if the bodies are soft and penetration is relatively great, the force of the blow must be relatively small, because, as said, the product of the two must be constant.

As an example let us take a 2000-pound drop hammer and let it fall upon the work from a height of 5 feet. Now, neglecting friction in order to simplify matters, when that hammer was raised up to the height of 5 feet by the driving mechanism, the work done upon it was the product of the weight and the distance, or 10,000 foot-pounds.

When released, the hammer will fall and, again neglecting friction, the 10,000 foot-pounds of stored work or energy which it received from the driving belt, will have been transformed into velocity and when it strikes the piece on the anvil block this velocity will again be changed back into work; the product of force and distance.

Suppose, for instance, that the deformation of the piece allows the hammer to sink down half an inch after it first strikes. This is the "distance" and is 1-24 of a foot. Since the total work available in the moving hammer head is 10,000 foot-pounds and since the distance moved through while the hammer is giving up this work is 1-24 of a foot, the average force exerted upon the piece must be 10,000 divided by 1-24 or 240,000 pounds. This is the force of this particular blow.

Now suppose the piece is harder than that just considered, and that when the 2000-pound head has dropped 5 feet, the penetration after striking the piece is only ¼ inch or 1-48 foot. Then by the same reasoning as before, the average force exerted must be 10,000 divided by 1-48 or 480,000 pounds.

Thus it is seen that the force of the blow depends upon the hardness of the body struck, for the harder it is, the less the penetration or "distance" and so, the greater the force of the blow must be.

Similarly, if the piece were very soft, and the penetration were, say 2 inches or 1-6 foot, the average force of the blow would be 10-000 divided by 1-6 or 60,000 pounds.

So far, we have considered only a falling weight. Let us return to the case of the rock drill. Suppose that a 3½-inch diameter drill has an average effective air pressure behind its piston, of 60 pounds per square inch; that the moving parts—piston, piston rod and steel—weigh 100 pounds and have a total stroke of 9 inches. Also let the penetration into the rock be 1-16 inch at a blow.

Here the problem is complicated by the work done by the air on the downward stroke. We will simplify the case by assuming that the air pressure is removed exactly at the instant of stopping and that there is no cushioning of air in the lower end of the cylinder.

In falling through the 9-inch stroke (¾ foot), the 100 pounds of weight will be able to do $100 \times \frac{3}{4} = 75$ foot-pounds of work. The average air pressure of 60 pounds per square inch above the 3½-inch diameter piston will exert a downward force of $60 \times 9.62 = 577$ pounds. This, acting through the 9-inch stroke, would put energy, or work, into the parts to the amount of $577 \times \frac{3}{4} = 432$ foot-pounds. This would show itself in increased velocity of the moving parts.

From this we have that the total work available in the descending mechanism, again neglecting friction, would be $75 + 432 = 507$ foot-pounds. Since the penetration is 1-16 inch or 1-192 of a foot, the average force of the blow will be 507 divided by 1-192 or 97,344 pounds.

Again, if the rock were very soft and the penetration were twice as great, the average force would be half as much or 48,672 pounds.

This same method of reasoning might be applied to a steam hammer with the result that a 24,000-pound hammer with a 36-inch diameter piston having 30 pounds average effective steam pressure behind it, dropping 6 feet and penetrating 1 inch would exert an average force of blow of 3,927,000 pounds.

A common-sense example of the fact that the force of this blow depends upon the resisting power of the piece struck, is that a

certain blow which would fracture a piece of hardened steel might do no harm at all to a piece of rubber. The steel would be penetrated so little that the enormous force resulting would fracture it, while the great movement of the rubber would allow the force of the blow to be so small as to do no damage.

The question may be asked, "What becomes of this work that is delivered by the falling weight?" It is used up in deforming and heating the piece which is struck by it, and also, to considerable extent, in the rebound of the parts, vibration of the earth, etc. This last phenomenon is a clear evidence of the force of the blow of a steam hammer. When the piece being forged is hot and soft, the vibration of the earth is nowhere near so great as when it becomes cold and hard, offering more resistance to the blow, with the same drop and steam admission.

As indicated, the force of the blow calculated in this manner is only the average force during the time of crushing the materials. At the first contact, the material would be softer than after compression and consequently the force of the blow delivered would be comparatively light at first, rapidly increasing to a high maximum many times greater than the calculated average, as the particles become more crowded together, stopping the motion of the falling hammer. For this reason the calculation of the actual "force of a blow" at any instant is even more indeterminate than might at first be supposed—*American Machinist.*

CONDENSERS WITHOUT AIR PUMPS

A new type of steam condenser in which the usual air pump is entirely dispensed with has appeared in Europe. Circulating and condensed water pumps are required, but the air is extracted from the air chamber by the circulating water on the ejector principle. The cold circulating water is drawn from the cooling tower tanks by a contrifugal pump, which imparts to it sufficient head to overcome the tube friction and to raise it to the top of the towers. The water enters the condenser with a somewhat higher velocity than is usual, and first passes through an ejector apparatus in the air chamber, which entraps the air, causing it to be carried out of the condenser with the circulating water. This arrangement is said to be suitable for any kind of steam plant, especially where a high and steady vacuum is required. Several such condensers are at work in Germany. One installed at Charlottenburg gave, it is reported, on test a vacuum of over 95 per cent. Both the pumps, that for circulating the cold water and that for the extraction of the hot condensed water, may be of the centrifugal type, and this fact, coupled with the absence of an air pump, reduces to a very large degree the liability of stoppages.

Although the circulating water pump is necessarily somewhat more powerful than in ordinary condenser plant of equal capacity, the total power required for the auxiliaries is said to be reduced. The chief advantages claimed for the system are the low running costs and the greater safety of working. Further, there is said to be a saving in first cost and in floor space.

TUNNELING UNDER AIR PRESSURE

There is considerable difference between horizontal and vertical excavation. In vertical work there are no overlaying strata. In the case of the tunnel the weight of material overhead becomes a very serious factor indeed. An air tension equal to the hydraulic pressure will keep the water out from every direction. But the solid material overhead may, under exceptional circumstances, be pressed down by a pressure comparable with its actual weight. This is about two and one-half times that of water. Under ordinary conditions the overlying strata are self-supporting a short distance above a tunnel. Between the lowest point of self-support and the roof of the tunnel lies material whose fall is to be expected. The air pressure, whether great or small, cannot be relied on to support this. The reason for this circumstance is the porosity of the soil. If the compressed air could not penetrate the earth and get above it and the imbedded boulders, then the air pressure might be expected, ordinarily, to assist in keeping the roof intact. But with the air pressure above and below its particles the same, the material will fall under the influence of gravitation. It is necessary, then, to provide an air pressure to withstand hydraulic thrusts and a mechanical support to oppose the weight of overlying loose material.

WEIGHING THE ATMOSPHERE IN DETAIL

The modern chemist is a modest man. He is not wont to boast of his achievements, nor to lay claim to a godlike knowledge of earthly things. And yet up to 1894 he thought that he knew all that there was to be known about the composition of air. In that year two distinguished English physicists announced that they had found a new gas in our atmosphere. Apart from the value of that achievement the discovery was of interest because the new gas, unlike any of the other constituents of air, refused to combine with other substances. Because of this lack of chemical affinity the gas was named "argon" (the idle one).

Since the discovery of argon, still other unsuspected constituents of our atmosphere have been discovered by Sir William Ramsey. Besides argon, he has given the world "neon" (the new one), "krypton" (the hidden one), and "xenon" (the stranger). All of these gases are contained in the air in infinitesimal quantities.

In the course of his investigations of these rare gases Sir William Ramsey found it necessary to weigh given amounts of them. He was confronted with the difficulty of not possessing a balance delicate enough; for these gases are marvelously light. Accordingly he set about the construction of one. It has recently been completed, and may well be regarded as the most delicate balance in the world.

So sensitive is this weighing apparatus that it is housed in a subterranean chamber, where the temperature is constant all the year round and where it will not be disturbed by street vibrations. The weighing must be done also in a dark room; for an ordinary light would markedly heat the instrument and vitiate its readings. When properly adjusted, the scale will detect a difference in weight of one seven-billionth of an ounce.

The utter impossibility of securing weights small enough to weigh a gas so light as xenon or krypton has rendered it necessary to employ the gases themselves as weights. The tiny tube in which one of these gases is contained is placed upon the scale and a reading is taken. Thereupon the tube is opened and the gas released and the inrushing air exhausted. Once more the tube is weighed. The difference between the two weighings is the weight of the gas.

The finest metallic weight thus far made weighs one one-million-five-hundred-thousandth of an ounce—much too coarse for weighing the rarer gases.

So slight is the movement of the scale beam that it cannot be detected by the eye, and must be magnified. Hence, the weight of the gas is indicated by a small mirror, upon which a minute pencil of light is thrown and reflected upon a graduated black scale.—*Saturday Evening Post.*

TIDES OF THE ATMOSPHERE

Most people know that tides are caused by the pull of the moon and sun on the waters of the earth; but knowledge that tides are also caused in the upper air is not quite so universal. Our earth is surrounded by a big ocean of air, which has a great deal more mobility than water or anything else we can imagine. The moon is the chief attracting force, and, consequently, a great hump is made in our air directly beneath the moon, and is held in place by the moon's attraction. This hump always points toward the moon, and as the earth rotates the hump travels around it.

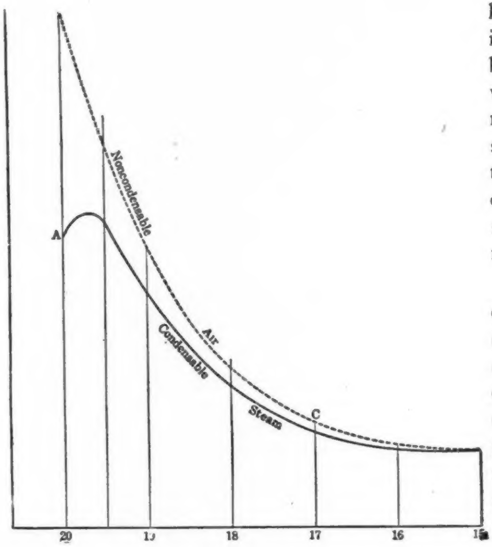
Aerial tides are like water tides: they appear in like phases at opposite points on the earth; so we should have two aerial tides every day, as we have two water tides daily. As the air is easier in its motion, so the hump can follow the moon easier. This would make the aerial tides come just before the water tides at any particular point on the earth.

As to the relation of these tides to man, not much was said until the flying machine succeeded in reaching great heights. Then their effect had to be taken into account.

The most wonderful thing in the aerial line, however, is the top current sweeping around the earth. It is of course understood that the earth rotates from west to east. The air, being free to move, follows the earth in varying velocities only until, when the uppermost regions of the air are reached, the rate of its velocity is far behind that of the earth, which is a thousand miles an hour. This being the case, it would have the effect of a current going from east to west at a velocity determined by the slowness with which it followed the earth. This velocity is approximately 76 miles an hour.

The way in which it was determined is his-

torical and somewhat interesting. In the '80's a volcano known as Krakatua sent forth over a cubic mile of matter. Much of this, being very light, was carried into the uppermost regions of the atmosphere. It was observed by people all over the earth; for it made the complete circuit of the globe no less than seven times. People now living can recall the glorious sunsets occasioned by reflected sunlight on the clouds of dust. Its average rate of travel was 76 miles an hour.



RECOMPRESSION OF STEAM AND AIR

The advent of the steam engine indicator, and its general use by the leading engineers did more to develop the details of economical steam engineering practice than all the abstract reasoning of all the engineers who had preceded it. This it did largely by still farther stimulating the reasoning faculty, but at the same time supplying checks and guides for the reasoning. The discussions are as lively as ever, and still there are questions which are far from settled. Recently in the technical press, and especially in Power and the Engineer, there has been discussion of the effect and value of the recompression of a portion of the steam remaining in the cylinder upon the return stroke. The compression of a considerable volume of the steam for the purpose of filling the clearance space in the cylinder, instead of filling it at every stroke with new steam from the boiler, has been approved by many, but a careful measuring of steam actually consumed has not shown the expected saving.

The explanation is furnished by the indicator. In a great many cases there has appeared in indicator cards taken from steam cylinders a hook at the upper termination of the compression line, as at *A* in the accompanying diagram, and this has been variously accounted for. A favorite explanation has been that this hook when the pressure has risen sufficiently is caused by leakage of piston or valves, or both. If leakage was the cause the same hook would appear when the same pressure was reached if compressed air was used instead of steam as the motor fluid. As a matter of fact the hook does not appear when air is used, the compression line running up with perfect smoothness until the end of the stroke is reached, as shown in the diagram.

Elaborate and protracted investigations conducted by Professor Dwelshauvers-Dery, a resume of which forms the *piece de resistance* in a recent issue of Power and the Engineer, demonstrated that the more compression his engine had the less the energy it developed per pound of steam consumed, on account of the condensation which occurred, a phenomenon entirely absent in similar compression of compressed air.

AN AERIAL LIGHTHOUSE

There has been keen discussion in Germany regarding the best methods for enabling aerial travelers to establish their location after nightfall and in foggy weather. While no one system has yet received official or professional sanction, an initial step has been taken at the town of Spandau in Prussia, where an aerial lighthouse is in full activity. It consists of an elevated support on which rests in a horizontal position a wooden ring of considerable diameter with 38 powerful incandescent lights around the circumference and an automatic arrangement for interrupting the current at regular intervals. A traveler over the place sees at night a large luminous circle alternatelv appearing and disappearing. This apparatus of course is of no use in fogs making it necessary to install also a siren or other noise maker.

OIL FUEL IN THE FOUNDRY

Taking into account convenience and cleanliness, oil is a cheaper fuel than coal for many industrial purposes. For this reason oil is being used to an increasing extent for baking cores, drying molds and heating ladles, and melting in brass, iron and steel foundries; for smelting, melting and refining in metallurgical establishments, and for a great variety of other processes where high temperatures are desired.

Where a furnace is used, it generally consists of a chamber, often of large dimensions, lined with firebrick, upon the floor of which is placed the object to be heated. The oil, together with some of the air for combustion, enters at one side from one or more jets or burners, and the burning blast impinges on the object to be heated. Sometimes the chamber is rectangular and the jets are directed immediately upon the object. In other cases there are bays or side-chambers to give opportunity for complete combustion previous to the main chamber. There must, of course, be an outlet for the products of combustion after they have given up their heat. A furnace of this type is much simpler than one where coal is used as fuel, for with coal there must be a grate, a combustion chamber and an ash-pit. There is, in addition, the expense of firing, clinkering and removal of ashes. Oil fuel is usually stored in tanks and delivered by pumps, and the storage and delivery are usually a simpler problem than in the case of coal.

So far as cost of a heat unit is concerned, coal is possibly a cheaper fuel at the present price of oil; but taking into account all of the incidentals, the total cost with oil is, in many cases, much less.

Two kinds of oil are in use at the present time. One is crude oil just as it comes from the well, while the other is a residue remaining after some of the more valuable products have been extracted. The nature of this residue varies considerably at different places and at different periods.

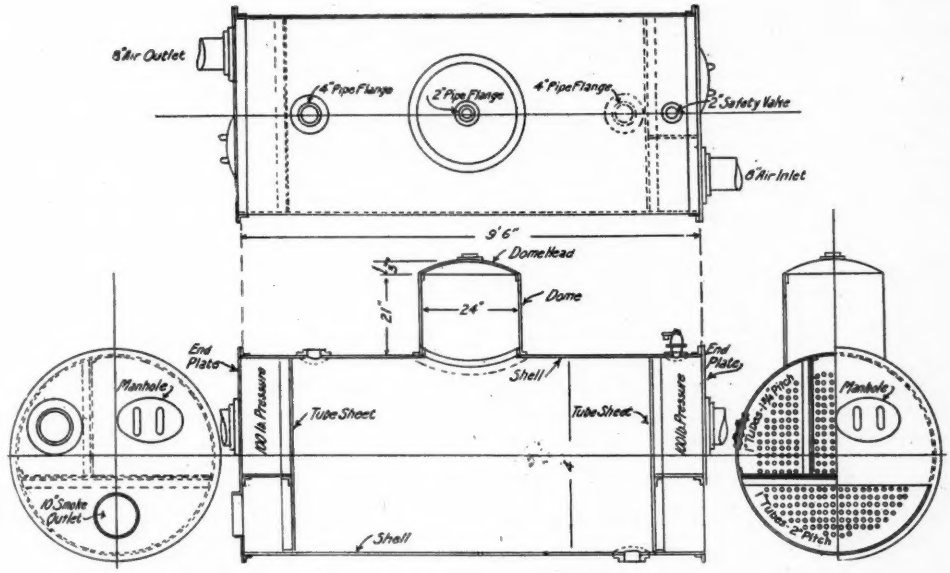
In order that the oil may burn in a proper manner and in a reasonable space without smoke, it must be intimately mixed with the air necessary for combustion. The oil is, therefore, reduced by a "burner" to very small drops, each surrounded by air for its combustion. This is called atomization. The drops must be of very small size, since a drop of appreciable size, even though it is surrounded by the entire amount of air necessary for its combustion, will proceed for a considerable distance from the burner, as a small ball of yellow flame, before it is completely burned.

The burners for producing the proper type of jet are of many shapes. There is always a pipe carrying oil under pressure leading through the burner. There is usually an additional pipe carrying compressed air or steam for the atomization. In the case of oil burners for steam boilers the jet is usually steam, while for industrial purposes the jet is usually compressed air. Some of the air for combustion is entrained or sucked in by the velocity of the jet issuing from the burner. In the case of steam atomization the entire amount of air must be supplied in this way. With air atomization the amount supplied under pressure and the amount entrained differ with the type of burner. There are many standard burners on the market, and, in addition many of the plants which burn oil have special devices of their own. The arrangements are, therefore, numerous, and no general description can be given. There are, however, the following general classes:—

The compressed air may be supplied at a pressure of from 15 to 30 pounds per square inch. In such cases the compressed air usually forms a comparatively small portion of that necessary for combustion, and the main air is entrained by the high velocity or sucked in by the chimney draft. In one such system the main air is supplied by a forced draft given by a fan blower delivering the air through a pipe ending near the burner at a comparatively low velocity.

In other cases the compressed air is supplied at a pressure of from 1 to 4 pounds per square inch. In these cases, probably the greater portion of the air is supplied by the compressor, and a comparatively small amount is entrained. However, it is difficult to make a positive statement in this matter. The designers of the various burners usually have their own ideas regarding the amount of air to be supplied, although these are often only approximate.—*Foundry News.*

A locomotive on the Albuquerque division of the Santa Fe Railroad has run 232,894 miles without going to the shop for repairs.



OIL HEATER FOR COMPRESSED AIR.

OIL HEATER FOR COMPRESSED AIR

The efficiency obtained by re-heating compressed air is well understood. In re-heating, however, it is important to secure uniformity of temperature, and this is difficult to maintain when the heat is applied directly by passing the gases from the burning of fuel around coils or chambers through which the air circulates. The accompanying illustration shows a most efficient and economical heater, designed by Gerald Sherman, superintendent of the mining department of the Copper Queen Consolidated Co., at Bisbee, Arizona, and erected by him at the Holbrook shaft. In this heater a heavy oil is employed as a medium to transmit heat to the air-pipes, which latter pass through the oil-container. This oil is a residue from the partial distillation of the lighter compounds from crude petroleum, the residue having a gravity of about 12 degrees Beaumé, and a flash-point of 700. The heater consists of a boiler 7 ft. 6 in. long by 4 ft. diam., provided with a dome which is open to the atmosphere. An 8-in. air-pipe admits the compressed air to a chamber at the rear lower side of the boiler, from which it is conducted through 1-in. tubes which make two turns within the boiler, causing the air to travel three times the length of the container in contact with the oil. One large flue, 10 in. diam., also passes through the lower part of the boiler for the heated gases. The boiler is set in brick-work in the ordinary way, the grate extending the full length from front to back. On this grate a coke fire is maintained, which raises the temperature of the oil to about 335 degrees F., although it can be brought to 360 degrees. Coke at Bisbee costs $10 per ton, and the amount consumed in re-heating the air does not exceed 400 lb. per day. The temperature of the air as delivered to the hoisting engine is usually about 315 degrees F., and the temperature of the exhaust is from 32 to 40 degrees. In a 27-minute test the consumption of free air per shaft horse-power was 24.4 cu. ft. Another test of 40 minutes' duration with air at a temperature of 355 degrees showed a consumption of 28.7 cu. ft. of free air per shaft horse-power. The total work done in this test was 58,441,980 foot pounds, or a total shaft horse-power of 1771. Approximately 75 lb. of steam at the power-house equalled one shaft horse-power at the hoist. In this test the weight hoisted was weighed, and allowance was made for rope-friction and all loses. These re-heaters are being installed at the several subsidiary shafts of the Copper Queen, and hoisting by air will be used exclusively. It is found that the economy is greater than by transmitting electric current for this purpose.—*Mining and Scientific Press.*

THE ISOTHERNAL STRATUM AND THE COLDEST REGION OF THE UPPER ATMOSPHERE

A report has recently been published giving the results of the remarkable series of sounding-balloon ascensions executed in equatorial Africa by the expedition under Beson and Elias sent out by the Royal Observatory of Lindenberg. Among the interesting data given perhaps the most important are those relating to the temperatures of the upper air.

It may be said to be known by all mankind that the temperature of the air decreases thermometrically as the altitude increases, as exemplified by the familiar fact that the top of a mountain is colder than the base, although apparently occasional inversions of this may occur, as when fruit trees are frost-bitten in a valley while those on the adjacent hilltops escape. Other considerations apply, however, in the explanation of this latter phenomenon.

Until Teisserenc de Bort announced his discovery of the isothermal layer, eight years ago, it was not suspected that this decrease of temperature did not extend upward to the limits of the atmosphere. Now, however, we know that at a certain altitude, averaging, in middle latitudes, about 11,000 meters (7 miles), the fall in temperature with increasing altitude ceases rather abruptly, usually giving place to a *rise* of temperature for a certain distance upward, above which the temperature remains approximately constant as far as the highest ascents of sounding balloons have carried thermometric apparatus.

Hence, above any given spot on the earth's surface the air is coldest just below the region of the upper inversion, which marks the beginning of the great isothermal layer (or, as it is now called by its discoverer, the *stratosphere*).

The altitude of the isothermal layer varies with the barometric pressure at the earth's surface, with the season, and especially with the latitude. It is somewhat less over the poles than over middle latitudes, and very much greater over equatorial regions than anywhere else in the world. In other words, the decrease of temperature with altitude continues to a much greater height within the tropic than elsewhere, and this explains the fact that the lowest temperature ever registered in the atmosphere was met with almost exactly over the equator, viz.,—84.3 deg. C. (—119.7 deg. F.), at an altitude of 19,300 meters (about 12 miles), at Shirati, on Victoria Nyanza, August 30th, 1908.

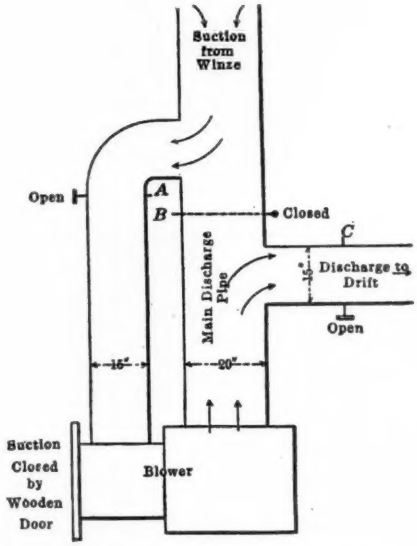
A NEW PROCESS FOR THE FIXATION OF ATMOSPHERIC NITROGEN

Atmospheric air is a mechanical mixture (as distinguished from a chemical compound) of oxygen and nitrogen gases—that is, the nitrogen in the air is in elementary form, mixed, but not combined with other elements. The importance of the problem of the "fixation" of atmospheric nitrogen rests in the fact that elementary nitrogen, as contained in the air, is inert and practically useless, while nitrogen compounds are of great commercial and industrial value, especially in the fertilizer industry. The object of the fixation of atmospheric nitrogen is simply to change the elementary nitrogen of the air into a useful nitrogen compound.

Since there are various useful nitrogen compounds there are various fixation processes possible. The simplest in idea is to take the oxygen and nitrogen in the air, as it is, and to try and combine as large a portion of them as possible directly into nitrogen oxides (to "burn the atmospheric nitrogen") and then work them up into nitric acid or nitrates. This can be done by subjecting atmospheric air to a very high temperature by means of electric arc discharges, as is done with commercial success in Norway in the process of Birkeland & Eyde and in the Schoenherr process of the Badische Company. The disadvantages of this method are twofold: The first product of the reaction is a dilute mixture of nitrogen oxides in atmospheric air and its transformation into nitric acid is complicated and not inexpensive; and secondly, the electric power consumption is high and the process is commercially practical only in countries where electric power is exceptionally cheap and where there is little incentive to use the available cheap power for other purposes. Norway is the classical example of such countries.

Another useful nitrogen compound is calcium cyanamide, which may be used either directly as fertilizer or as starting material for the manufacture of other chemicals, like cyanide. In the manufacture of calcium cyanamide the air cannot be directly used, but it is first necessary to separate the nitrogen from the oxygen in the air (for instance, by fractional distillation of liquid air); the nitrogen

is then made to react with calcium carbide at an elevated temperature, yielding directly cyanamide. The power consumption is not so high as in the nitric acid process mentioned above. Nevertheless, the production of calcium cyanamide, being based on calcium carbide manufacture, also requires comparatively cheap power.—*Metallurgical and Chemical Engineering.*



REVERSING AN AIR CURRENT

The sketch, here reproduced from The Engineering and Mining Journal, shows a simple piping arrangement for reversing the air current from a fan blower. The scheme is employed on the 2000-ft. level of the Union mine, at Virginia City, Nev., where a Sturtevant, multivane blower is used to supply air to a winze from which levels are being opened. The main discharge of this blower is 20 in. in diameter and the fan is run at 1120 r.p.m., being belt connected to a 20-h.p. motor. The power consumption is about 16 horsepower.

Ordinarily the fan is used merely to blow fresh air down the winze through the 20-in. main-discharge pipe. After blasting, it is, however, necessary to draw the foul air and gas from the winze. The 20-in. pipe then acts as a suction pipe, the air current being drawn (into the blower) through the parallel length of 15-in. pipe and discharged through the 20-in. pipe and connecting 15-in. pipe. A wooden door or gate is used to close the suction end of the blower and the gates *A, B* and *C* in the pipes control the air current. The sketch shows the blower drawing air from the winze and discharging it into the drift. After clearing out the winze the door is removed from the suction of the fan, valves *A* and *C* closed, *B* opened, and fresh air is blown into the winze.

It is much quicker and more economical to draw out bad air than to force it out by blowing in fresh air. In the winze mentioned, no time has to be lost between shifts even though the temperature of the air would quickly rise to above 120 deg. F. if artificial ventilation were not resorted to.

A NEW REFRIGERATING MACHINE

A new refrigerating machine has recently been exhibited in London of which we have as yet only a crude description. As described it consists of two closed copper cylindrical vessels mounted on a horizontal spindle. The spindle, being tubular, affords a passage between the vessels, which are revolved on a light framework by means of a crank handle. In operation, one of these cylinders, charged by the makers with a liquid of special composition, is heated by a flame, while the second is cooled by a spray of water, a slow rotary movement being given to both meantime. The heating causes vapour to pass from the liquid in the first cylinder into the second one, where it is condensed. The flame is then extinguished, and the second cylinder is covered with a water-tight hood, which is filled with water. This having been done, the water spray is directed on the first cylinder, and as it cools, owing to the vacuum which is formed, the liquid condensed in the second cylinder evaporates and passes into the first cylinder, where it is absorbed by a hygroscopic medium. The cooling produced by the evaporation in the second cylinder cools the water in the hood, and eventually causes it to freeze. It is claimed for the machine that no dangerous chemicals are employed; that the charge of freezing liquid does not lose its efficiency; and that, in regard to maintenance, the cost of the heating, which is effected by two methylated spirit lamps, is the only expense. At the demonstration about 10 lb. of ice was produced in slightly over an hour from the starting of the machine.

FOR HOUSE AND OFFICE COOLERS

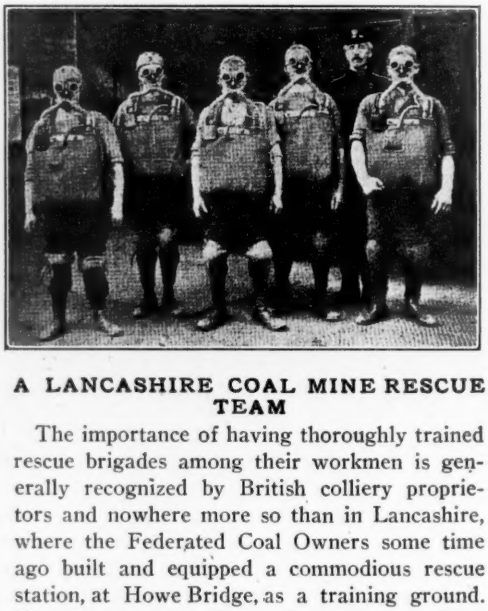
Among the favors conferred by a generous republic upon its valued servant, President Taft, is an office room that at this season of the year is artificially cooled, just as in Winter it is artificially heated. Not only is this doubtless very pleasing to the President, since what may be called his personal architecture is such as to make him feel more than some other people the discomforts of hot weather, but it is probably a profitable use of public money, since it will enable him to do more work and better by diverting his attention from the tropic fervors of a Washington Summer.

Now, when one comes to think of it, there is difficulty in understanding why humanity has always realized the need of mitigating the severity of climate that takes the form of cold, but for the most part still assumes the impossibility of doing anything to temper heat, from which we suffer almost as much. At less expense than that by which houses are warmed in Winter they can be cooled in Summer, and, while the Winter heating, thanks to our strange refusal to learn the art of ventilation, involves the creation of conditions injurious to health, those which Summer cooling would establish would probably be in every way beneficial to us. At any rate, the thing is perfectly practicable.

Of course, if adopted, it would add to the cost of living, but it would also increase the general stock of available energy, which would mean an increase of earning power to a more than compensating degree. Not much of a refrigeration plant would be required to bring the air of a bedroom to a temperature in which sleep would be refreshing, instead of impossible or exhausting, and the wonder is that the rich, and the well to do, at least, do not generally, instead of hardly at all, utilize a benefit which science is ready to give them for much less money than they pay for a thousand other smaller luxuries and conveniences.—*N. Y. Times.*

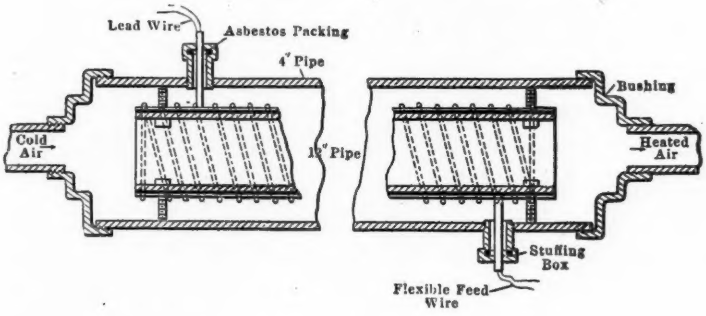
ARTESIAN WATER PREDICTIONS

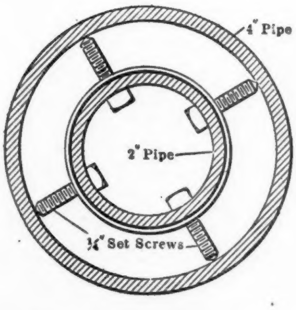
An excellent example of the utility of geologic predictions based on geologic knowledge is shown by the extensive investigation of underground water carried on by the U. S. Geological Survey, affording a basis for predicting flows in several areas, some of the predictions having been remarkably verified. At Edgemont, S. D., a well was sunk by the Burlington railroad company. Mr. N. H. Darton of the Survey was consulted and predicted that water could be expected in the Deadwood sandstone about 3,000 ft. below the surface. The boring was begun, but meeting with many difficulties and reverses, there was a disposition to abandon it. The engineers, however, had confidence in Mr. Darton's prediction and urged continuance, resulting in a great flow of water being struck at 2,695 ft. The well yields a half million of gallons a day of tepid water satisfactory for locomotives and other uses in a region where there is no water for 60 miles. Similar predictions have been verified along the extension of the Chicago, Milwaukee & St. Paul railroad and the Chicago & Northwestern.

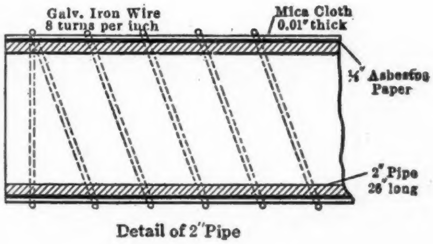


A LANCASHIRE COAL MINE RESCUE TEAM

The importance of having thoroughly trained rescue brigades among their workmen is generally recognized by British colliery proprietors and nowhere more so than in Lancashire, where the Federated Coal Owners some time ago built and equipped a commodious rescue station, at Howe Bridge, as a training ground. Here teams drawn from all parts of the Lancashire coalfields have been grounded in all branches of rescue work, interesting competitions having been arranged to test the capabilities of the different teams. The Earl of Ellesmere, who is the largest private coalowner in the County Palatine, has formed a rescue brigade of his own, drawn from his various pits. The striking little half tone shows a rescue tram with their instructor. Many workmen from his lordship's collieries have been trained at Howe Bridge, and could be relied upon to act in emergencies.







Detail of 2" Pipe

ELECTRIC COMPRESSED AIR REHEATERS

At the Bully Hill copper mines in Shasta county, Cal., a novel type of reheater is used in connection with pumps operated by compressed air. The arrangement is an electrical resistance coil inclosed in a pipe through which the compressed air passes directly before being utilized. The arrangement was worked out by H. A. Sutliffe, electrician for the Bully Hill Copper Mining and Smelting Company, and has proved thoroughly satisfactory.

The reheater consists of two principal parts, i. e., an outer jacket and an inner length of pipe upon which is wound the resistance wire. The air line is bushed to the pipe jacket and through this jacket are tapped, as shown in the drawing, two ½-in. holes provided with insulated stuffing boxes through which the flexible, lead wire is connected to the resistance coil.

In the design shown the resistance coil is wound on a section of 2-in. pipe, 26 in. long, the jacket pipe being 4 in. in diameter. The central pipe is first wrapped with 1-8-in. asbestos paper, and this in turn covered with mica cloth 0.01 in. thick. Over this is wrapped a helix of No. 14 galvanized-iron, telephone wire pitched eight turns to the inch. At points 1 in. from either end, the central pipe is tapped for set screws at four equally spaced points about its circumference. These set screws serve to keep the resistance coil from touching the outer pipe jacket. The wire coil is so wound as to not touch the set screws.

A reheater, as described, is designed for a 110-volt 40-amp. current and will use approximately 6 h. p., yet at the Bully Hill mine a saving of at least $6 per month has been effected, it is claimed, by each reheater installed. The reheaters are credited with raising the available air pressure 5 lb. [This statement is misleading. The effect of reheating in this case would be to increase the working *volume* of the air instead of the pressure, thus-reducing the volume required to be furnished by the compressor. Ed. C. A. M.]

With the electric reheater it is well to have the valve controlling the air engine, pump, etc., for which the air is being heated, connected with a pilot light, so that when the engine is shut off, attention will be called to that fact at once and the reheater will be disconnected. If this is not done there will be danger of burning out the reheaters as they soon become hot enough to destroy themselves if allowed to run after the air is cut off.—*Engineering and Mining Journal.*

ECONOMY OF THE PIECE WORK SYSTEM IN HANDLING SUPPLIES*

If we are going to get the largest possible output for the smallest cost, we must interest the man doing the work more than paying him by the hour. A man's interest must be vital if we are to get the best there is in him. We must pay for what we get, and not for what we do not. We must get 100 cents worth of work for every dollar paid out. This the piece work system accomplishes, as its organization and introduction shows.

At first blush it would seem to be a difficult matter to resolve the handling of supplies into given factors or units. This is not so, as we have a unit to issue or receive everything we handle in the store department, and a record to refer to that is permanent. Lumber is handled per thousand feet B. M. Iron, castings, coal, sand, etc., are handled by the ton. Pipe is handled by the foot. Mixed merchandise is handled by per package of 100 lbs. or less, over 100 lbs. to 200 lbs., etc. Filling requisitions and delivering material to the shops is handled by per item, per piece or per pound, depending upon the kind of material and the local conditions.

Filling requisitions and delivering material shows a very large saving put in piece work, due to the amount of lost motion that creeps in under the day work basis. Shop men will ask what has happened to the store men after they have been put on piece work, as they no longer stop to talk, but drop the material and hurry away for more. The men group their work, taking or getting all the material wanted from the different sections at one time. One foreman, planning the getting and placing of material, is only one part efficient as compared with a whole gang of four to eight men planning the same thing. In establishing piece work for a delivery gang composed of foreigners, who did not know the material and could not understand English, the prices were based on what was considered fair. The foreigners could not make one-half their day rate with the prices set, and were transferred. English speaking laborers were hired in their place, and they, being able to use their heads, made from 30 to 50 cts. per hour.

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*A paper by D. C. Curtis before the Railway Storekeepers' Association, St. Louis, Mo., May 16-18, 1910.

The men should be given to strictly understand that after a price is approved it will not be changed unless conditions are changed. They can make as much money as it is possible for them to make, and will be paid accordingly. As soon as the men are assured that they will be paid for what they do they will work their heads as well as their hands and feet, and will take advantage of everything possible. For instance, in one of our yards a derrick gang use long bridge bolts to handle 6-in. cast-iron pipe. These bolts are put in the end of the pipe to slip the sling around, enabling them to handle very quickly six to ten pieces at a time. These bolts are carried on the derrick to be used when needed. When loading a small order the men run ahead of the derrick with bolts and sling and load the pipe without stopping. It is impossible to get work done this way at an hourly rate, but there is money in this method for both the men and the company, as shown below:

Work done on hourly basis on which price was based:

Labor	$2.50
Use of derrick	2.00
Total	$4.50

Work done piece work in one-half the time:

Labor, P. W. rate	$2.00
Use of derrick	1.00
Total	$3.00

Saving, $1.50, of 33⅓ per cent.

We had four men in one of our lumber delivery gangs and the day we were about ready to start piece work one man quit, and the other three refused to work until another man was put in his place. The piece work system was explained to the three men, and they were asked if they would do the work on this basis, which they agreed to do. Soon after, one of the three left the service of the company, and the remaining two are handling this work, together with a large increase, in about 70 per cent. of their regular working time, making a high rate of pay. The company is saving one man's time and about 30 per cent. of three men's time on this particular work.

At one of the large icing stations, where an average of 100 cars per day are iced, and some days as many as 250 cars, it was necessary un-

der the day work system to take a large force of men from one of the other departments to help during rush hours. However, since piece work has been installed the regular force has handled the work without delaying a single train or having a complaint from the shippers. The men know the more they hurry the more they make.

On one of the scrap docks it was impossible under the day work system to keep the pile of miscellaneous mixed scrap sorted and cleaned up as fast as it came in with the regular gang assigned to this work, it being necessary to put on additional help to prevent congestion. Ninety days after piece work was installed the regular gang cleaned up this scrap without additional help, and now take care of it and have time to do other work; yet a better foreman than the man in charge of this dock cannot be found.

It is impossible to work unintelligent foreign laborers to advantage. A gang cannot be divided, sending one man for a given article, another to the shop for manufactured material and have others sorting out material. The foreman has to take the whole gang with him, or have part idle, to get even a given size of bolt or article of any kind, as the thing wanted has to be pointed out and motions used to direct their movements.

With the piece work system we are able to hold the men after we have them educated. In May, 1908, a storekeeper hired 50 Austrians who had just come to this country, and they after becoming familiar with the conditions, were put on piece work. Thirty-five of the original 50 are still working for this storekeeper, one having died and the others leaving the service. The men are making good wages, and it is needless to say they are an efficient force. For increased and intelligent effort men make enough for the work to be attractive. The longer men stay, the more proficient they become, the more money they make, fewer mistakes and breakages occur, and discipline is easier.

Piece work keeps men and methods of doing work out of ruts, as the men are continually scheming short cuts and new kinks. It gives us machines and tools with which to handle work quickly. To show a saving in having machinery to handle material is a very simple problem in arithmetic when on a piece work basis; i. e., lumber handled by hand costs 5 cents to 85 cents per 1,000 ft., B. M.; with a derrick, 15 cents per 1,000 ft., B. M.

Piece work forces the storing of material in the most convenient places for handling. In one of the large new storehouses recently built the connecting rods for engines are kept in a closed rack in the center of the house, without lifts of any kind to handle them with. Piece work would very quickly show the saving to be made by putting these rods where they could be handled with a small crane at a great saving.

Piece work gives a contented set of men, each man in business for himself. Men would rather work piece work than day work, as is shown by the engine men and trainmen being paid by the mile, miners by the ton, etc. These men would not think of going back to the hourly unit. The rapid, intelligent workman receives wages in proportion to work done; ability is paid for.

A CONTRACTOR'S MELODRAMA

A contractor decided that he would write a play in which the hero would be a plain but honest contractor who would cop the girl and the wealth in the last act and live unhappily ever after. He wrote his play and has given us the privilege of giving a synopsis of it. This we have done for the purpose of showing that there are strong dramatic possibilities in the life of a contractor. The plot of the play, in brief, is as follows: Tom Jones, a young contractor, is in love with Mame Brown, daughter of Dunne Brown, president of the Hot Air Line. Brown awards Tom the contract for building a 100 mile railway, one of the conditions being that if the work is completed by 10 a. m., Nov. 15, Tom secures the daughter as a bonus; if the work is unfinished at that time Dunne Brown gets the road for nothing. Goodrich Mudd, 1st vice president of the road, is also in love with Mame but is spurned by her, as he already has two wives. He plots to foil Tom and is ably assisted by J. Little Work, 2d vice president of the road. Bill Smith, assistant chief engineer of the road, is a friend of Tom's and comes to his rescue at various critical moments. A summary of the four acts follows:

Act I. Grading camp at night. Enter foreman, skinners, hoboes, waterboys, etc., singing, "It's 14 miles to the nearest drink, and you have to walk all the way." Supper; song,

"What, beans again?" Mule skinners by light of banjo torches skin two mules that had died from fright at the sight of oats.

Act 2. Scene in Tom Jones's tent. Enter bill collectors for feed men, grocerymen, butchers, etc., etc. "I'm busted." Bill Smith: "Take this $10,000, my last month's pay." It begins to rain; it pours; high water; floods; tempest; hurricane. Glanders in the stock. Steam shovel busted. Concrete mixer blown-up. "There's deviltry in the air."

Act 3. Scene 1, headquarters of chief engineer. "We allow no rock in this estimate, it's all earth." "My God! it cost me $1.25 per cu. yd." Scene 2. Court. 56 experts on one side, 56 on the other. "The judge finds that this is rock and holds you to the terms of the contract."

Act 4. Site of bridge, 9.45 a. m., Nov. 15. Pile drivers, hoists, cableway from distant cliffs to bridge site, etc. Tom Jones discovered tied beneath hammer on ponderous pile driver. Goodrich Mudd and J. Little Work prepare to let hammer drop. Mame Brown and Bill Smith appear on distant cliff. "My God! We're too late." "Quick, the cableway bucket." Bang! Bang! Just in time. Ten minutes to finish the work. In with a pile. "Who'll run the engine?" "I, Mame Brown." "It's down. The railroad is completed. I've won my bonus."—*Engineering-Contracting.*

VACUUM FOUNDATIONS

"Vacuum" foundations—so miscalled—are being exploited in Germany. Under this arrangement foundations proper of masonry or timber, and also foundation bolts, it is claimed, may be dispensed with for machine tools, steam engines, air compressors, etc. The normally level floor—cement, wood, asphalt or what not—is used as it is, provided it is strong enough to bear the load. Between the machine and the floor there is laid a soft rubber plate or mat. The patentee claims a vacuum action, but this, on an average machine tool or steam engine, that has only a few planed strips on the under side of the base, would be hardly worth considering. It seems to be a fact, however, that steam engines and machine tools are running on such mats, without being secured to the floor, and this has not only the advantage of cheapness and rapidity of construction, but also that a machine may be readily moved and set running in a new place.

From the legal standpoint, also, machines thus set do not form part of the real estate, as they would if secured to a foundation. There is even a trifle less noise, and electric machines are insulated from ground contact. In the Imperial Exhibition for Improving the Conditions of Workmen, Frauenhoferstr, 12, Charlottenburg, several machines thus set have been on exhibition, running since March, 1907. In the Borsig Locomotive Works, Tegel, near Berlin, a 45-hp. horizontal reciprocating steam engine is running on such a mat, unbolted.

WASHING THE AIR

A reporter for a Chicago daily paper, in telling of a trip through the new Blackstone Hotel, writes as follows:

"Let us visit the air laundry," said the chief at length.

He opened a door, projected an electric lantern through the dark, and disclosed a splashing sheet of water. Through this Niagara air was being driven with tremendous force.

"Look below!" boomed Mr. Boomhower. "That pool contains the dirt which is removed from the incoming atmosphere *every minute.*"

All glanced at the inky water. Chief Steward Muller gasped. Mr. Tompkins whistled what must have been "the Air Washed Life Is the Life for Me!"

DRY AIR MEAT PRESERVING

Some experiments have been made in Sydney, Australia with a "dry-air process" of preserving meat, which seems to promise auspicious results. Some of this meat after being treated by the new process has been hung up in bags, and then after about 15 days opened in the presence of veterinary surgeons and commercial men and found quite fresh. The inventor of this "dry-air process" claims that for $100 a station owner can put up the necessary plant and treat sheep at a cost of one cent per carcass, and after being treated by this new process the meat may be hung in any ordinary place and atmosphere and kept good for a week. The period of treatment is about 14 hours. Some of this meat, according to the Herald, of Taranaki, New Zealand, from cattle and sheep killed at Sydney between December 7 and 14, arrived in Wellington, New Zealand, on the 22d, having been carried in the ordinary vegetable hatch on the deck of the vessel, and when examined by the press representatives was quite sweet and sound.—*Consular Reports.*

COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC

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CONTENTS

COMBUSTION AND EXPLOSION

The fatal explosions in coal mines, which seem to be little nearer to reliable control and complete prevention than half a century ago, are compelling special investigation at the present time with some hope of ultimately attaining greater safety. When we begin our investigations of these explosions we naturally first of all wish to know what are the conditions and what the sequence of events in the case of an explosion, or what, in fact, an explosion really is.

If there be any precise point of demarcation between the familiar action of combustion or burning, as of a candle or of an ordinary wood or coal fire in grate or stove, and that of explosions so-called, whether explosions of the common explosives, as gunpowder or dynamite, of explosive mixtures of comminuted hydro-carbons and atmospheric air, as in the gas or oil engine, of mixtures of air and inflammable gases in coal mines, or explosions of mixtures with air of finely powdered combustible material, as wheat flour, fine sawdust or coal dust, we do not know where that point is located.

Indeed, a tolerably clear understanding of the entire series of phenomena may be arrived at by regarding them all as of the same class, the only element of difference being in the time consumed by the specific event. An explosion we may regard as a rapid fire, and an ordinary fire we may call a slow explosion. There is nothing instantaneous, or without the expiration of time, but a sequence of causes and effects in each case, the one demonstrably preceding the other.

For combustion in general we must have some so-called combustible material, something having an active affinity for oxygen, and we must have the oxygen, usually as contained in atmospheric air, these to be in intimate contact or capable of such contact, when they will be ready for the burning, which however, will not begin until a sufficiently high temperature is produced, although after combustion begins the temperature is usually self sustained or augmented.

In the act of combustion the combustible and the oxygen unite in certain definite proportions, so much combustible to so much oxygen and vice versa. In the burning of a solid this proportion is self maintaining, as the burning is upon the exterior surface of the solid combus-

tible and proceeds slowly or rapidly according to the access of the oxygen.

When combustible gases and atmospheric air are intimately mixed, the oxygen present being just sufficient in quantity for the amount of combustible, then we have a so-called explosive mixture, which is ready for complete combustion throughout its entire mass if it can be raised to the temperature required for ignition. Combustible solids if ground to fine powder and then mixed with the proper proportion of air form explosive mixtures whose combustion occurs apparently in the same manner and with the same results as with the strictly gaseous mixtures. Dust of any readily burning material seems to be capable of combining with air to form an explosive if fine enough and intimately mixed in the right proportions. Wheat flour, sawdust, and frequently coal dust, have been the agents of disastrous explosions.

Professor Paul Spier, of Breslau, tells us of an explosion of a mill in which zinc dust was being sifted for market, the dust in the air providing the combustible element of the explosive mixture. This should not be at all surprising to any one who has ever melted zinc in an open ladle. The melting point of zinc is only slightly above that of lead, and yet the zinc takes fire as soon as it begins to melt, and if the surface of the metal is not protected much is wasted by the burning. The ready combustibility of the zinc thus cannot be questioned, and the dust of it when mixed with its due proportion of air would be fired, we may assume, by a spark or other means giving a firing temperature no higher than that required for firing the coal dust mixture.

The proportion of coal dust in air to constitute an explosive mixture has been quite definitely determined. At the Lievin station, in France, the lowest density at which ignition was invariably produced was 70 grams (1,080 grains) of dust per cubic meter (35.315 cubic feet), and below a density of 46 grams (710 grains) per cubic meter only negative results could be obtained. An experiment by Galloway has shown that 1 pound of average coal dust will render explosive 160 cubic feet of air. More exhaustive data along this line are being accumlated at the Pittsburg testing station.

We have intimated that the essential difference between ordinary combustion or burning and explosion is in the time occupied. That is in the event as a whole. In the details of the explosion operation an important element enters which in a sense annihilates time, this being in the initial pressure generated. At the point where the mixture is first fired the volume of the constituents is greatly increased, and this local increase of volume results in a sudden increase of pressure throughout the mass, this increase of pressure being accompanied—not followed—by a corresponding rise of temperature, the rise of temperature extending to and above the ignition point, and then the entire mass is fired, or, as we might say, it fires itself all through and all at once, and this we call an explosion.

THE COAL MACHINE PROBLEM

The advent of machinery in any line of industry is likely to transform its methods and to change its products or results more or less. The work and the workers make concessions and accommodate themselves to the ways of the machine to secure its advantages. The rock drill, for instance, has radically changed the planning and the working of the world's great engineers. From before the time of the Romans down to the building of the first Croton aqueduct water was conducted in open channels, with just enough descent to permit an easy flow; and to secure the necessary level the line meandered tortuously along the edges of the hills, and costly works were required to cross the valleys and the streams.

Now the rock drill makes the pressure tunnel possible and cheap, and it is driven by straight lines from point to point. In this respect the coal machine is more or less an anomaly, in that it gets so few and small concessions from the work it undertakes to do. Mining conditions can be but little changed to accommodate the machines, and it is the machines which must be adapted to the conditions. The coal mining machine undertakes to supersede the hand-work pick, and it must work in just the same situations in which the hand pick has been worked. Generally, too, the man who has worked the pick, perhaps for years, becomes the manipulator of the machine when it is introduced. It is, of course, at all times largely dependent upon the skill and judgment of the man who handles it, and as the hand pick is of widely different effectiveness in different hands, so the machine makes different showing, according as it is handled.

As the conditions of coal mining vary so much, especially as to thickness and pitch of the seam and the hardness of the coal, it is not to be expected that any one style or size of machine will be universally suitable, and we might even expect ultimately a wider series than yet exists. The coal machine may, in the long run, expect fair play, and will win upon its merits.

From official notes upon coal mining machines, so far as they have been fairly tried, the following claims have been made for them: There is an increase in the proportion of lump coal produced, a greater yield per acre, reduced working cost, reduction in the amount of explosives required, reduced cost for timbering, and fewer roof falls; larger daily wage for the collier, while relieving him from the most laborious and dangerous work.

Coal-cutting machines, so-called, are not new, having been tried in Great Britain more than half a century ago, but with so little success or encouragement that, so late as 1902, there were only 166 machines in use. In 1907, however, there were 1,493 machines.

With regard to coal machines in the United States, there are some interesting figures, but not very closely up-to-date. The number of machines in use increased from 7,663 in 1904, to 9,184 in 1905, and to 10,212 in 1906, 5,911, or 58 per cent., of this number being of the pick or puncher type. The percentage of increase in the production of machine-mined coal in 1905 over 1904 was greater than the percentage of increase in the total production. In 1906 the quantity of machine-mined coal was 15,451,075 short tons greater than in 1905, while the total production of bituminous coal increased 21,534,643 tons, showing that 72 per cent. of the increase was in the machine-mined product. The average output for each machine in use increased from 10,258 tons in 1904 to 11,258 tons in 1905, and to 11,638 tons in 1906. The percentage of machine-mined coal to the total production in 1899 was 23; in 1900, it was 25.15; in 1901, 25.68; in 1902, 27.09; in 1903, 28.18; in 1904, 28.78; in 1905, 33.69; and in 1906 it was 35.10.

A new height record for aeroplanes was made by W. H. Brookins at Indianapolis when with a Wright biplane he reached an altitude of 4,503 feet. His engine gave out and he made a sensational glide to the ground.

COMPRESSED AIR IN VENTILATING

The practice of turning compressed air into a ventilating pipe to induce an air current is said to be common in the Coeur d'Alene mines. This is quite a simple and inexpensive method of ventilating drifts when compressed air is at hand and power to operate a fan blower is not available. On the 1,200-foot level of the Hecla mine at Burke air is drawn in this manner 500 feet from the face of a drift to the shaft. Twelve-inch pipe is used, and a piece of ¾-inch pipe turned up at the end serves as the air nozzle. The air current is in this instance sucked 500 feet through the fan pipe, the air-jet being introduced into the fan-pipe about 15 feet above the bend at the shaft.

A different scheme is used on the 1,600-foot level of the Mace mine. Here the air-jet is applied within a few feet of the suction end of the fan-pipe. In this manner a current of air is forced 400 feet to the shaft through an eight-foot fan-pipe. The nozzle in this case is made of one-half-inch pipe bent in circular shape to fit around the interior of the fan-pipe. The coil is drilled with a number of one-eighth inch holes on the side opposite the suction end of the fan pipe. It is claimed that this acts as a more efficient nozzle, and requires much less air than does turning in the air in a single jet. These nozzles may be used at a number of places in the fan-pipe if one will not draw a current of air sufficient for proper ventilation.

THE OLDEST COLLIERY LEASE

The following, believed to be the earliest known colliery lease or agreement, was recently published as an appendix to the presidential address of Dr. J. B. Simpson before the Institution of Mining Engineers:

"Thys indenture made betwix William the Priour of Duresme of that part and John Brown of Tudhowe, Bertrame Gaytherd, Alexander Belfielde, William Litham, Rollyn Drensmyth of Middleham, and William Brown of Duresme flesshewer on that part, witnesse that the said Priour has granted and to farm lettyne to the said John, Bertrame, Alexander, William, Rollyn and William a wast tofte and 28 acres of land with the appurtenances in Trillesden and with a colepit in the same lande therein to work and *wyn cole* every day overable with thre pikkes and ilk pike to wyn every day overable 60 scopes. To have and to holde the

said toft and land with the appurtenantes and with the said colepit fra the feast of Seynt Cuthbert in Septembre next commyng for term of a yeer then next following; givyng to the said Priour for the said tofte and land with the appurtenances 24 *s.* and for the said colepit 10 marke of goode Inglish money at the feists of the Invencion of the holy croce and the nativite of Seinte John Baptiste rent comyng be even porcions. And the said John, Bertrame, Alexander, William, Rollyn and William sall werke the said myne werkmanlike, to save the feld standyng be the sight of certeyn vewers assigned be the said Priour ats oft as hym likes to lymet them within the same year to serche the same myn. In the witness of the whilke the partyes aforesaide has entrechangeably to this indenture sett their seales. Wreten the last day of August the yeer of our sovereign and gracious Lordo Jesus MCCCCXLVII. (1447)."

AIR CONSUMPTION OF ROCK DRILLS

"The rating of air compressors when expressed in the number of rock-drills to which they are capable of supplying air, is usually based upon a consumption of a volume of air at 60 lb. per square inch pressure, equivalent to about 100 to 110 cu. ft. of free air per *second.*"

This interesting paragraph seems to have been made by one of our technical contemporaries for a filler at the bottom of a column, but we find it reproduced verbatim by another most esteemed and usually most reliable exchange. It of course should be a minute instead of a second, and at least 80 pounds gage pressure should be suggested instead of 60, while the diameter of the drill cylinder should be mentioned as one of the necessary factors. Thus the above volume of free air should on the average be sufficient for a 3-inch drill, while for 10 drills of the same diameter not more than three-quarters of this per drill would be required, as all the drills on a job never work all the time or all together.

KEEP DYNAMITE DRY

Dynamite should never be stored in tunnels, nor in any place where dampness exists. Although a tunnel may seem dry, all rock-in-place contains from 3 to 8 per cent. of moisture, which is continually being brought to the wall surface in underground workings by capillarity, where it is evaporated unless, for want of ventilation, the air is saturated. Thus the rock is continually contributing moisture, which is greedily absorbed by the sodium nitrate in the dynamite, that salt being highly hygroscopic. As soon as the sodium nitrate has deliquesced, that is, melted from absorption of moisture, the homogeneity of the dynamite becomes disturbed and the "dope" fails to retain the nitroglycerine, which then leaks out. The water substance often seen on cartridge paper, and the oily stain seen in dynamite boxes, is due to the leaking of the nitro-glycerine. A cartridge in this condition is far more liable to accidental explosion than sound dynamite, and it is perilous and uneconomical in use. It will not develop the same energy as good dynamite; it is likely to burn and blow out instead of detonating properly, and it is a frequent cause of "mis-fires," and of the failure of a charge to explode to the bottom of a hole. Dynamite must be stored in a dry place. —*Mining Science.*

REHEATING COMPRESSED AIR WITH STEAM

The practice of reheating compressed air by mixing it with steam is employed generally in the Cœur d'Alene mines of the Federal Mining and Smelting Company. Results obtained at these mines seem to indicate that this is the most economical and efficient method of getting the full measure of energy from the air.

At the Mace mines, air at 90-lb. pressure for drills, and steam for the hoist were formerly conducted the 3000 ft. through the entry tunnel in separate pipe lines. The air is now compressed to 100 lb., mixed with superheated steam at the compressor house and piped into the mine in one line to supply both hoist and machine drills. The daily saving by this arrangement is figured at about $40, and, besides, an increase of 10 lb. in pressure is gained for drills. The steam plant formerly required 14 tons of coal per day, while from six to eight tons is all that is burned now. The boiler at this plant is rated at 80 h.p. and the capacity of the compressor is 4000 cu. ft. of free air per min. No trouble has been experienced from either freezing or condensation.

At the Morning mine the boiler for generating steam for reheating air will be situated at the underground hoisting station. The shaft will have four compartments and through it 1000 tons of rock per 24 hours will be hoisted.

The engine and drills will be run on a mixture of compressed air and steam.—*Eng. and Min. Journal.*

A PUNCTURELESS AUTOMOBILE TIRE

What is claimed to be a punctureless automobile tire has made its appearance in England. It comprises an inextensible heavy canvas lining, the crown being packed with a puncture-proof material and placed between the outer cover and the inner air tube of the ordinary pneumatic tire. The lining is so made as to cause a low pressure on the tread and to more nearly equalize the pressure on the inner air tube. The lining is thickest at the crown and tapers to a feather edge near the rim. The external appearance is like the ordinary tire. The inventor has given it drastic tests. He made several gashes and cuts on the outer cover of a tire through to the patent lining, and with these has driven his car 500 miles without a puncture or the necessity of repair on this tire, although wheels on the same machine fitted with other tires had the usual difficulties. Other tests on heavy cars without the special gashes have been equally satisfactory. An inspection of the invention impresses one with its simplicity, and the carved outer cover used and seen demonstrates that it is a great development in tires for use on automobiles.

A NEW GAS FOR BALLOONS

A new German invention of value for nondirigible balloons is reported by Consul Thomas H. Norton, of Chemnitz:

Illuminating gas is forced through long tubes, maintained at a very high temperature. Most of the carbon in the hydrocarbons is thus separated out and the percentage of hydrogen is largely increased, so that this gas constitutes 80 per cent. of the modified coal gas. At the same time it is deprived almost entirely of its characteristic odor, and freed from the presence of benzine, which exerts an undesirable solvent action upon the materials employed to render balloons impermeable. The most important change is that in buoyancy, as the specific gravity sinks from 0.44 to 0.225, or less than one-quarter the weight of air. This means that 1 cubic meter of the new gas can support a weight of 1 kilo (2.2 pounds). In coal gas, 1 cubic meter supports 0.7 kilo. A balloon with a capacity of 7,000 cubic feet, when inflated with the new gas, has a lifting power equal to that of a balloon of 10,000 cubic feet charged with ordinary coal gas.

NEW USE FOR SMALL HAMMER DRILLS

Small hammer drills are used with a chisel bit in the Hecla mine at Burke, Ida., for cutting off the crushed ends of timbers. In the stopes the greatest pressure is from the squeeze of the walls, and as the ends of the stulls and caps become splintered and crushed, it is necessary to cut them off and put in new blocking. It is often difficult to get at the crushed timbers, and, even when accessible, it is not an easy job to chisel or saw the wet and twisted fibers by hand. The cutting of the wood is rendered quite easy with the drills, and by using sufficiently long bits, almost any desired place can be reached. The drills and chisels may also be used to great advantage for chiseling wall plates when an extra shaft compartment must be added, or in cutting off posts to ease up drift sets in heavy ground. In a number of mines, the blocking on drift caps is shot out when it is necessary to ease up on the sets; this work can much more safely and surely be accomplished with the drill.—*Eng. and Mining Journal.*

CHLOROFORMING AN AIR LEAK

An engineer in charge of an extensive plant found that there was an air-leak in some new piping which had been placed as an extension of an existing sprinkler system. It was of the dry type with compressed air filling the pipes to hold back the water. The pipes were charged with compressed air at 85 lb., and after two days the pressure had fallen to 35 lb., which should not have happened for six weeks or two months. Soap lather applied to the outside of the joint failed to locate the leak, and the resourceful engineer said "We'll chloroform the pipe and catch it napping." He got 3 oz. of ether and poured it gradually into the suction of the compressor as it pumped the pressure up again to the required 85 lb. Foremen of the departments were asked to watch for the odor of ether and to report it to the engineer. For the first day nothing was reported, but on the second afternoon the leak was etherized and located at once in a joint of the old piping close to the new addition, caused

probably by abnormal strain when making the connection.

AN IMPROVISED AIR CUSHION

When some mine pumps delivering 1,200 gallons per minute against a head of 1,000 feet were first started considerable difficulty was experienced in obtainng quickly a sufficient air cushion in the air vessel of the discharge to prevent an annoying hammer. A remedy was found in an air-charging device. A length of extra heavy pipe, with blind flanges on each end, was placed alongside the pump. Connections were made from the air vessel to the pipe, and also from the column pipe and the air line in the mine. A drain was placed in the lower end of the pipe. To use this device, all connections are at first closed, except that to the air line, which charges the pipe with air at a pressure of 90 pounds to 100 pounds. The air connection is then closed, and that to the water column opened. This allows the pressure of the water in the column to compress the air. The column connection is next closed, and that to the air vessel opened. After charging the air vessel the pipe is drained of water, and the operation can then be repeated.

A COMBINATION AEROPLANE

Trials have been made in Berlin of an interesting machine invented by a German aviator named Grawert and designed to be used either as an automobile, a motor boat or an aeroplane. It is a combination of biplane and monoplane, and is equipped with a 50 horsepower Anzani engine, which is to propel the machine, with four passengers at the rate of 100 to 120 kiloms. (62 to 76 miles) per hour. To convert the flying machine into an automobile, the carrying planes are unfastened and then fixed to the body of the machine, so as to form the side walls of the automobile. The process of reconverting the flying machine into an automobile is calculated to take 30 minutes. During the trials on the uneven ground of the Tempelhofer Feld appreciated speeds were reached with four passengers in the chassis. An air propeller is used whether the machine is on land or water or in the air. For a machine of this type the word "amphibious" must be extended to apply to the third element.

NOTES

Contracts have been let for supplying dynamite to be used on the Panama Canal for the fiscal year 1911, the aggregate amounting to nearly 7,000 tons at a total cost of $1,658,000.

The Nelson (B. C.) Iron Works has taken over the business and stock of the Rossland Engineering Works, and will succeed that company as British Columbia agents for the Sullivan Machinery Company of Chicago.

In 1909, at the Ready Bullion mine, Alaska, 268,904 ft. of machine-drill holes broke 315,941 tons of rock, an average of 1.17 tons per foot of hole. The 700-Foot Claim mine broke 261,737 tons with 263,804 ft. of holes, an average of 0.99 ton per foot.

There were recently shipped to Paris six approximately cubical blocks of Indiana limestone having an average weight of 35 tons. The blocks go to the studio of a famous sculptor and after being carved into statues are to be returned to the United States to adorn the residence of a private citizen at Newport.

A coal dust burner using a jet of compressed air instead of a fan blast has been in successful operation for the past two years in a southern cement factory. Air at high pressure passes through a Koerting ejector nozzle and enters the kiln through a horizontal pipe. A vertical fuel supply pipe opens into the horizontal pipe just beyond the discharge end of the nozzle and between the nozzle and the kiln, the rapidly moving air jet carrying the coal dust into the furnace.

The British government has placed a submarine bell off the Lizard. It is suspended from a heavy tripod, which was lowered to the bed of the ocean at a point about two miles from land. The bell is connected by cable with the lighthouse, from which it will be operated. It is anticipated that, since steamers passing up the Channel all approach the Lizard, the bell will be of great assistance to them, particularly in time of fog.

A new kind of so-called Greek fire has been invented by a German officer. It differs from

the old Greek fire in that it is not employed in the incendiary shells by which ships were once upon a time destroyed, but is poured out on the water and directed against hostile vessels. The fluid which occasions this fire, and the composition of which will not be disclosed, is of such a kind that it floats on the water, and it is impossible to extinguish the flames.

A careful investigation is being made of the iron resources of Brazil. Reports from the various districts show the extent of the known deposits to be of such great magnitude that the ore in sight is sufficient to supply the world's demands for centuries to come. The government of Brazil has recently appointed a special commissioner to investigate the steel industry of the United States and to make arrangements for the exportation of the iron ores.

A recent earthquake in California, which caused little remark at the time of its occurrence, is said to have increased the water supply of the city of Corona, in that State. The Temescal Water Company secures its supply from the Coldwater, Mayhew and Gregory canyons. During the entire year the flow varies but slightly, but since the quake the total increase for the three canyons amounts to 75 inches. As water sells for $1,000 an inch, this increase is worth $75,000.

Of the 5,000,000 horse power theoretically available at Niagara Falls only 270,000 horse power, or 5.4 per cent. has thus far been utilized. Of this 126,000 horse power is employed in electro-chemical processes, 56,000 horsepower for railway service, 36,400 horse-power for lighting, and 45,500 horse-power for various industrial services. Nearly 125,000 horsepower is transmitted to points more than ten miles from the falls. Of this amount 12,300 horse-power is transmitted over a distance of more than 100 miles, while 33,500 horse-power is transmitted between 75 and 100 miles.

The fixation of atmospheric nitrogen by an entirely novel process is announced by Prof. Fritz Haber and Dr. R. Le Rossignal, Karlsruhe Institute of Technology. The process, it is reported, has already passed from the merely laboratory stage and is being developed by the Badische Analin und Soda Fabrik. The new process is the synthesis of ammonia (NH_3) from nitrogen and hydrogen under a pressure of 200 atmospheres and in the presence of a catalytic agent like osmium or uranium. High temperatures are avoided. The hydrogen is produced by any chemical process found desirable and the nitrogen is used as in the air.

Ozonized air is now used as an adjunct to ventilation in the Chicago Public Library, and it is claimed that among other beneficial effects it has completely freed the reading room from the obnoxious human odor which has been noticed for years. The air to be passed through the ozonizer is first washed. The ozone generator is installed in a large air duct in such a way that all the air is forced between the electrodes across which a potential of 7000 volts is maintained. The energy required for treating the air is said to be 660 watt-hours for 10,000 cu. ft. of air. The plant was installed by the National Air Filter Co., of Chicago.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.

JUNE 7.

960,275. RATE-INDICATING DEVICE FOR FLUIDS. FREDERICK N. CONNET, Providence, R. I.

960,361. ELECTROPNEUMATIC AIR-BRAKE SYSTEM. GEORGE MACLOSKIE, Schenectady, N. Y.

960,478. AIR-COMPRESSOR. DAVID R. ALLARD, Arleta, Oreg.

In an air compressor, a casing provided with a series of cells, each of said cells having an open end directly facing a body of water and being provided with a rear portion above the level of the front portion, all of said cells being arranged to be subjected to the waves of said body of water, air pipes connecting said air cells with a common air tank, valves in said pipes for retaining the air in said air tank, and other valves for permitting the entrance of air into said cells.

960,455. MOLDING-MACHINE. PETER FREDERICK WALSTROM, Birmingham, Ala.

960,531. PNEUMATIC-DESPATCH-TUBE APPARATUS. EDMOND A. FORDYCE, Boston, Mass.

960,539. AIRSHIP. ROBERT E. GREEN, New York, N. Y.

960,557. FRONT HEAD FOR DRILLING-MACHINES. GRANT KEMMERLING, Douglas Island, Alaska.

960,564. PNEUMATIC CLEANER. ELMYR A. LAUGHLIN, Chicago, Ill.

960,579. PNEUMATIC VEHICLE-GEAR. LOUIS J. PERKINS, Lewiston, Idaho.

960,609. VACUUM-PUMP. GEORGE S. WILLIAMS, Norfolk, Va.

960,610. POWER-PNEUMATIC. GEORGE S. WILLIAMS, Norfolk, Va.

960,633. BAROVACUUMMETER. GUSTAV FRERICHS, Hanover, Germany.

960,636. PULSATING DEVICE FOR MILKING APPARATUS. EZRA E. GOOD, Waterloo, Iowa.

960,656. PNEUMATIC-DESPATCH-TUBE APPARATUS. JAMES GAYTON MACLAREN, Weehawken, N. J.

960,729. COMPOUND LIQUID-PISTON AIR COMPRESSING AND PUMPING APPARATUS. JAMES K. SWEENY, Pueblo, Colo.

960,830. AIR-CONDITIONING APPARATUS. STUART W. CRAMER and WILLIAM B. HODGE, Charlotte, N. C.

960,857. DISCHARGE MECHANISM FOR VACUUM-TANKS. WILLIAM H. EGGERT, Buffalo, N. Y.

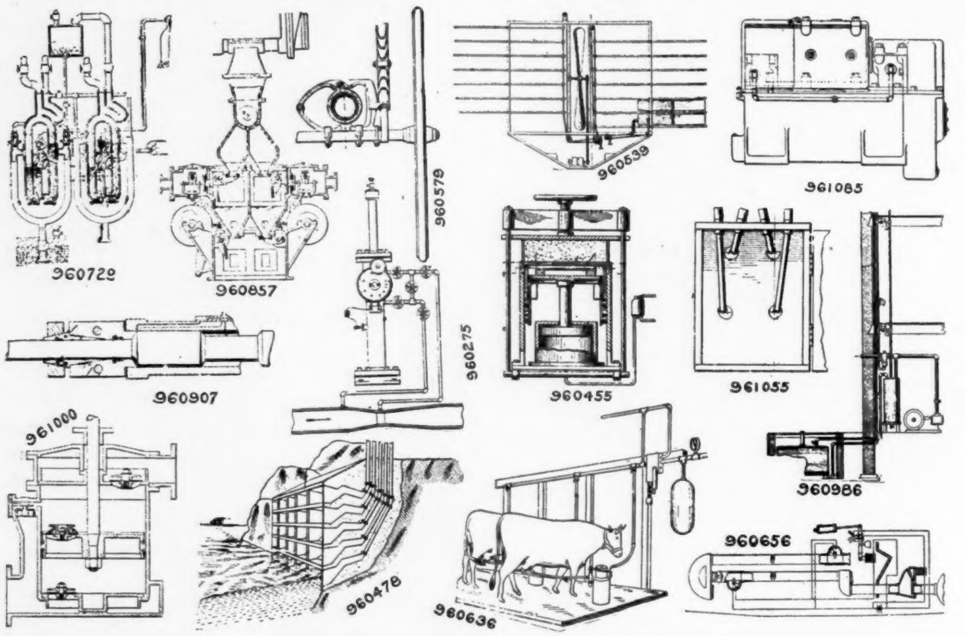
961,208. AIR-PURIFYING APPARATUS. GEORGE CLEMENTS and JAMES M. HOSTLER, Chicago, Ill.

961,231. AIR MATTRESS, SEAT, AND THE LIKE. NEHEMIAH C. HINSDALE, Marion, Ind.

961,271. WINDMILL. ALFRED M. VOLD, Chicago, Ill.

961,306. APPARATUS FOR THE PROPULSION OF SHIPS. CHARLES ROBERT MAYHALL, Arroyo Grande, Cal.

A vessel provided with compressed air tank, a pipe extending longitudinally from end to end of the vessel and discharging through the center of opposite ends thereof below the water line, valves arranged near the ends of said pipe, laterally extending pipes arranged near the front end of the vessel and opening through the opposite side walls thereof at points diametrically



PNEUMATIC PATENTS, JUNE 7.

opposite, and similar pipes arranged at the rear end of the vessel, said lateral pipes having valves arranged therein, means for communication between the first-mentioned pipe and compressed air tank and steam pipes extending longitudinally through the tank to heat and expand the compressed air therein in order to increase the pressure thereof.

960,986. AIR-CONTROLLED FEED SYSTEM FOR LIQUIDS. EDWARD J. MOORE, Cleveland, Ohio.

961,000. AIR-PUMP FOR USE WITH CONDENSERS AND THE LIKE. PHILIP FRANCIS ODDIE, London, Eng.

961,055. PNEUMATIC ANNUNCIATOR AND INDICATOR. CLARENCE B. WITHROW, Denver, Colo.

961,085. MOTOR-COMPRESSOR. WILLIAM H. LIEBER, Milwaukee, Wis.

JUNE 14.

961,104. MEANS FOR AUTOMATICALLY INFLATING PNEUMATIC TIRES. ROGER CONNELL, Westport, New Zealand.

961,144. COMPOSITION OF MATTER FOR REPAIR OF PNEUMATIC TIRES. JOHN H. LEWIS, Joplin, Mo.

2. The herein-described composition of matter for the treatment of pneumatic tires to prevent the escape of air when punctured consisting of ribbon glue 39 pounds, water 1½ gallons, molasses 1 gallon and 1 pint, linseed oil 5 pints, chrome alum 5 oz. 100 gr., bichromate potash 4 oz. 330 gr., water sufficient to make 25 ounces, substantially as described.

961,307. PNEUMATIC SPINDLE. REUBEN H. MORRE, Jeffersonville, Ind.

961,310. MEANS FOR OPERATING RAILWAY-BRAKES. SPENCER G. NEAL and JOSEPH M. CHILDRESS, Los Angeles, Cal.

961,317. HIGH-PRESSURE COMPRESSOR OR OTHER POWER-ABSORBING MACHINE. AUGUSTE C. E. RATEAU, Paris, France.

961,320. AIR-BRAKING APPARATUS FOR RAILWAYS. WILLIAM H. SHEASBY and SPENCER G. NEAL, Los Angeles, Cal.

961,364. BLOWER-UNLOADING DEVICE. JAMES G. MACLAREN, Weehawken, N. J.

961,365. HANDLE FOR MASSAGE APPARATUS. THOMAS A. MCCALL and CHARLES M. SIEBERT, JR., Columbus, Ohio.

1. A handle for massage apparatus made up of sections fitted together and provided with suitable filtering means, said handle being adapted to communicate with a vacuum pump,

one of the sections of the handle being provided with perforations to regulate the force of the vacuum.

961,427. PRESSURE-REGULATING DEVICE FOR PNEUMATIC TIRES. CORNELIUS J. BROSNAN, Springfield, Mass.

961,456. SPRAYING-MACHINE. JAMES G. MASTIN, Chicago, Ill.

961,638. STEAM AND AIR PIPE COUPLING FOR CARS. RICHARD BENJAMIN PAINTON, Williamsport, Pa.

961,658. WINDMILL. JOHN A. SWANSON, Canton, S. D.

961,710. MEANS FOR DRYING AIR. LOUIS BLOCK, Mamaroneck, N. Y.

JUNE 21.

961,766. WIND-MOTOR. THOMAS H. E. FOLGER, Corral, Idaho.

961,788. SINKING SHAFTS OR THE LIKE. DANIEL E. MORAN, Mendham, N. J.

1. In the sinking of shafts or the like, the method which consists in introducing air alongside the shaft to facilitate its descent.

961,932. PULSATOR FOR MILKING-MACHINES. DAVID BROWN, Spokane, Wash.

962,386. AIRSHIP. GEORGE D. S. REECE, St. Louis, Mo.

JUNE 28.

962,511. FLUID-PRESSURE IMPACT-ENGINE. JOHN KINCAID, Vancouver, British Columbia, Canada.

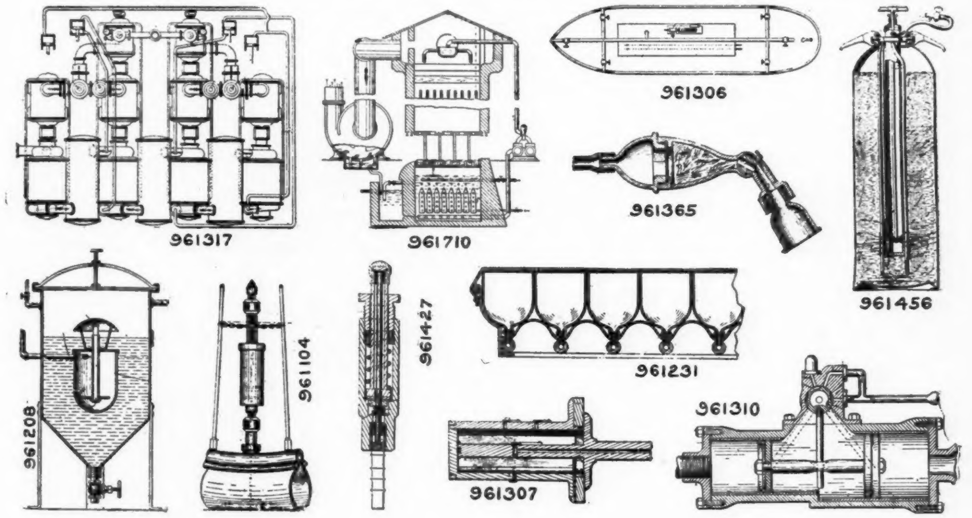
962,517. AIR-BRAKE. JAMES F. MCELROY, Albany, N. Y.

962,534. COIN-CONTROLLED PNEUMATICALLY-OPERATED MUSICAL INSTRUMENT. THORNTON I. SHANNON and FRED M. GARNETT, Columbus, Ohio.

962,546-7. AIR-BRAKE APPARATUS. HENRY F. BICKEL, New York, N. Y.

962,537. TEMPO-CONTROLLER FOR AUTOMATIC PIANOS. ALBERT H. STUART, Boston, Mass.

2. In an automatic piano, a pneumatic motor, an exhaust pump and conduit communicating therewith, said conduit including a pneumatic and a port opening into the pneumatic, and a valve mounted on the movable wall of the pneumatic so as to move endwise in and out of said port, said valve having a controlling surface inclined to the line of travel and formed of graduated width narrower toward the ends and broader between the ends.



PNEUMATIC PATENTS, JUNE 14.

961,960. MILKING-MACHINE. MILTON A. HICKS, Weathersfield, Vt.

961,999. PNEUMATIC-TUBE SYSTEM. BIRNEY C. BATCHELLER, Philadelphia, Pa.

962,019. DIVING-BELL APPARATUS FOR SUBMARINE WORK. JOHN GARNAR FLOOD, Westcliffe-on-Sea, and WILLIAM GEORGE FITZGERALD, West Ealing, England.

962,045. CARRIER FOR PNEUMATIC-DESPATCH TUBES. ALBERT W. PEARSALL, Lowell, Mass.

962,068. PNEUMATIC STACKER. JAMES A. WALSH, Indianapolis, Ind.

962,072. PNEUMATIC-DESPATCH-TUBE APPARATUS. LOUIS G. BARTLETT, Somerville, Mass.

962,203. GAS-COMPRESSOR. RALPH W. EMERSON and FRANK BISHOP, South Bend, Ind.

962,217. AIR-GUN. GEORGE E. HECKMAN, Brice, Tex.

962,246. PNEUMATIC SPRING. ALBERT F. ROCKWELL, Bristol, Conn.

962,284. AIR-COOLING APPARATUS. ROBERT G. WILSON, Alaska, W. Va.

962,350. ROCK-DRILL. HERMAN J. HIBSCHLE, Victor, Colo.

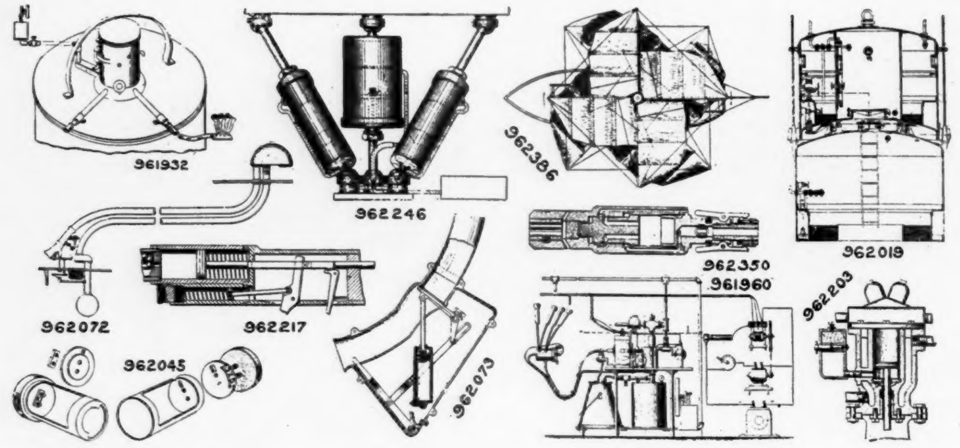
962,569. PNEUMATIC CLEANER. FREDERICK H. HIRTH, Grand Rapids, Mich.

962,592. COMPRESSOR. HENRY D. SHELTON, Hughesville, Mo.

1. In an apparatus of the class described, two spaced air compressing pumps having reciprocating pistons in alinement and means for causing the simultaneous actuation of the pump pistons comprising a rotatable member having its axis of rotation parallel with the longitudinal axis of the pumps and its periphery extending beyond the longitudinal axis of the pumps, rollers engaging opposite sides of the said member adjacent to its periphery, and drums on each side of the rotatable member and of less diameter than said rotatable member, each of said drums being provided with an actuating flange or ledge engaging a respective pump piston rod.

962,612. MEANS FOR EXTRACTING GOLD FROM RIVER-BEDS. JOHN H. BATTEN, Jamestown, Cal.

A device of the character described comprising a drum, means admitting compressed air to said drum, a man way disposed at right angles to



PNEUMATIC PATENTS, JUNE 21.

said drum, a door opening from said man way to the atmosphere and a door opening from said man way into said drum.

962,688. AUTOMATIC BELL-RINGER. CHRISTIAN AALBORG, Wilkinsburg, Pa.

962,696. STRAIGHT-AIR-BRAKE ATTACHMENT FOR AUTOMATIC SYSTEMS. WILLARD R. CHANDLER, Branchville, S. C.

962,713. ELECTROPNEUMATICALLY-OPERATED CONTROLLER. JOSEPH N. MAHONEY, Wilkinsburg, Pa.

962,717. VALVE FOR HAMMER-DRILLS. VINCENT J. O'BRIEN, Denver, Colo.

962,720. DEVICE FOR EQUALLY DIVIDING AND DISTRIBUTING A CURRENT OF AIR. HENRY F. RAND, Tacoma, Wash.

962,755. ELECTROPNEUMATIC TRACK-CHANNELER. ARTHUR HENRY GIBSON, Easton, Pa.

962,796. CARRIER FOR PNEUMATIC-DESPATCH-TUBE APPARATUS. CHARLES F. STODDARD, Boston, Mass.

962,797. PNEUMATIC-DESPATCH-TUBE APPARATUS. CHARLES F. STODDARD, Boston, Mass.

962-853-4. PNEUMATIC-DESPATCH-TUBE APPARATUS. ALBERT W. PEARSALL, Lowell, Mass.

962,901. MASSAGE APPARATUS. HENRY C. KARPENSTEIN, New York, N. Y.

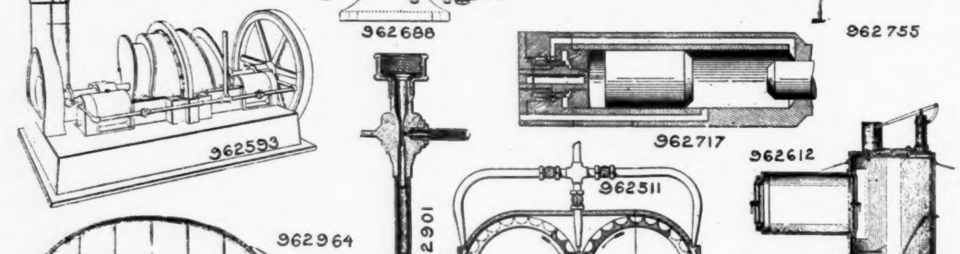
1. A massage apparatus comprisng a fluid-conduit, an air-conduit opening into said fluid-conduit, a valve in the air-conduit, and a massage implement connected with the air-conduit.

962,964. AIRSHIP. THEODORE KORNBRODT, Chicago, Ill.

962,977. AIRSHIP. AUGUST RICHARD RIEGER, Chicago, Ill.

962,980. AUTOMATIC AIR-BRAKE COUPLING. FORREST H. ROE, Batesville, Ohio.

963,010. HYDROCARBON-BURNER. IRA L. OWENS, Effingham, Kans.



PNEUMATIC PATENTS, JUNE 28.

Blowing Engines.
Cooper Co., C. & G.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.

Brakes, Air.
Westinghouse Air Brake Co.

Channelers.
Galigher Machinery Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Charging Stations.
Baldwin Locomotive Works.
Porter Co., H. K.

Coal Cutters.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Coal and Ore Elevator Buckets.
Clark Co., W. J.
Galigher Machinery Co.

Compressors, Air and Gas.
Bury Compressor Co.
Chicago Pneum. Tool Co.
Curtis & Co., Mfg. Co.
Galigher Machinery Co.
Gardner Compressor Mfg. Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Pangborn Co., Thomas W.
Powell Co., Wm.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Westinghouse Air Brake Co.

Compressor Fittings, Air and Gas.
Chicago Pneum. Tool Co.
Galigher Machinery Co.
Gardner Compressor Mfg. Co.
Mason Regulator Co.
Powell Co., Wm.
Republic Rubber Co.

Compressor Regulators.
Chicago Pneum. Tool Co.
Gardner Compressor Mfg. Co.
Mason Regulator Co.

Core Drills, Diamond.
Sullivan Machinery Co.

Core Drills, Diamondless.
Galigher Machinery Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Core Making Machinery.
Pangborn Co., Thomas W.

Corliss Engines.
Cooper Co., C. & G.
Galigher Machinery Co.
Sullivan Machinery Co.

Drilling Machines, Pneumatic.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Pangborn Co., Thomas W.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Drill Sharpeners.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
T. H. Proske.

Dust Exhaust and Collector Systems.
Pangborn Co., Thomas W.

Electro-Pneumatic Machinery.
Galigher Machinery Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.

Engine Room Appliances.
Galigher Machinery Co.

Fans, Ventilating.
Galigher Machinery Co.
Sullivan Machinery Co.

Foundry Appliances.
Chicago Pneumatic Tool Co.
Curtis & Co., Mfg. Co.
Ingersoll-Rand Co.
Pangborn Co., Thomas W.

Foundry Facings.
Jos. Dixon Crucible Co.

Graphite Commutator Brushes.
Jos. Dixon Crucible Co.

Graphite Crucibles and Retorts.
Jos. Dixon Crucible Co.

Graphite Greases.
Galigher Machinery Co.
Jos. Dixon Crucible Co.

Graphite Paint.
Galigher Machinery Co.
Jos. Dixon Crucible Co.

Hammer Drills.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Hammers, Calking and Chipping.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Oldham & Sons Co., Geo.
Pangborn Co., Thomas W.
Stearns-Roger Mfg. Co.

Hammers, Riveting.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Oldham & Sons Co., Geo.
Pangborn Co., Thomas W.
Stearns-Roger Mfg. Co.

Helmets, Sand Blast.
J. M. Betton.
Pangborn Co., Thomas W.

Hoisting Machinery.
Galigher Machinery Co.
Lidgerwood Manuf. Co.
Sullivan Machinery Co.

Hoists, Air.
Chicago Pneumatic Tool Co.
Curtis & Co., Mfg. Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.

Hose Coupling and Clamps.
American Metal Hose Co.
Chicago Pneumatic Tool Co.
Clark Co., W. J.
Cleveland Pneumatic Tool Co.
Curtis & Co., Mfg. Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Sprague Electric Co.
Sullivan Machinery Co.
Westinghouse Air Brake Co.

Hose, Sand Blast.
Pangborn Co., Thomas W.

Hose, Steam and Air.
American Metal Hose Co.
Chicago Pneumatic Tool Co.
Curtis & Co., Mfg. Co.
Galigher Machinery Co.
Goodrich Co., The B. F.
Ingersoll-Rand Co.
McKiernan Drill Co.
Republic Rubber Co.
Sprague Electric Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Locomotives, Compressed Air.
Baldwin Locomotive Works.
Galigher Machinery Co.
Porter Co., H. K.

Lubricating Graphite.
Jos. Dixon Crucible Co.
Galigher Machinery Co.

Lubricating Greases.
Borne, Scrymser Co.
Fiske Bros'. Refining Co.
Galigher Machinery Co.

Lubricating Oils.
Atlantic Refining Co.
Borne, Scrymser Co.
Continental Oil Co.
Fiske Bros'. Refining Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Standard Oil Co.
Vacuum Oil Co.

Lubricators.
Powell Co., Wm.

Magnetic Separators.
Pangborn Co., Thomas W.

Meters, Air.
Ingersoll-Rand Co.
Metric Metal Works.
St. John, G. C.

Mining Machinery.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Motors, Air.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.

Nozzles, Air and Sand.
Curtis & Co., Mfg. Co.
J. M. Betton.
Pangborn Co., Thomas W.

Oil Cups.
Galigher Machinery Co.
Powell Co., Wm.

Ore Concentrating Machinery.
Galigher Machinery Co.
Stearns-Roger Mfg. Co.

Packings.
Clement Restein Co.

Pile Drivers, Pneumatic.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.

Pipe Joint Compound.
Galigher Machinery Co.
Jos. Dixon Crucible Co.

Plug Drills.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
Oldham & Sons Co., Geo.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.

Pumping Systems, Pneumatic.
Bury Compressor Co.
Curtis & Co., Mfg. Co.
Galigher Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.

Pumps, Air.
Cameron Stm.Pump Wks,A.S.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Pumps, Pneumatic Displacement.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Pumps, Steam.
Cameron Stm.Pump Wks,A.S.
Galigher Machinery Co.
Stearns-Roger Mfg. Co.
Westinghouse Air Brake Co.

Quarry Machinery.
Bury Compressor Co.
Cameron Stm.Pump Wks,A.S.
Chicago Pneumatic Tool Co.
Galigher Machinery Co.
Ingersoll-Rand Co.
McKiernan Drill Co.